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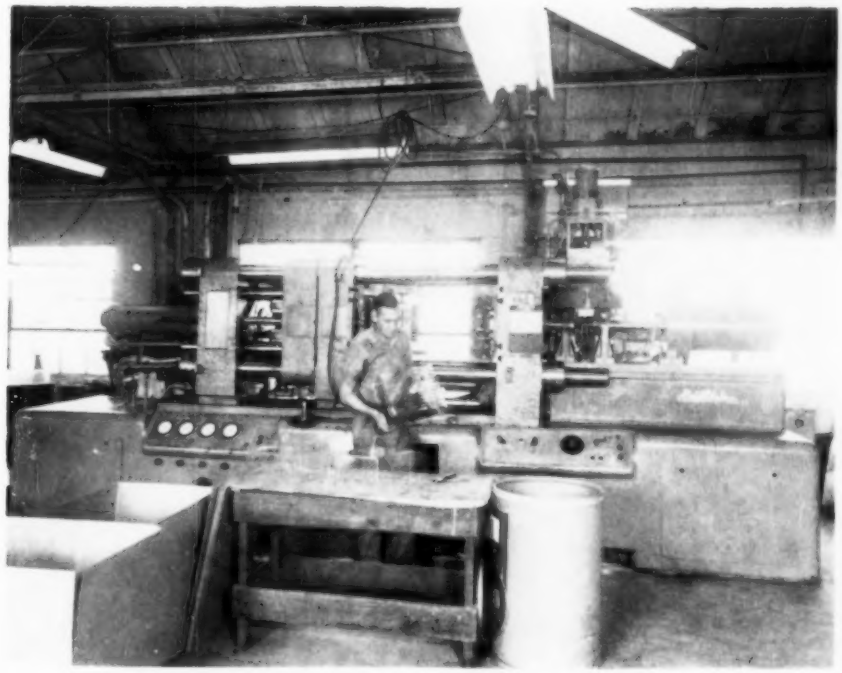

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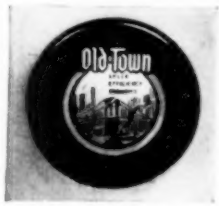

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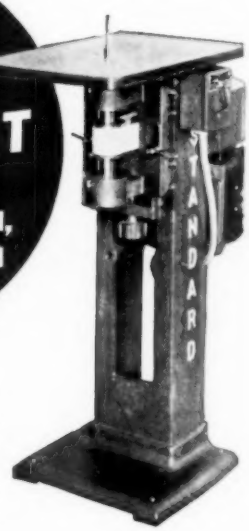

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President's Message

Your National Council has selected me to guide and direct the activities and fortunes of the National Office of the Society of Plastics Engineers by electing me president of your Society.

I am honored.

I address this to the many members who were unable to attend and take part in our Sixth Annual Technical Conference and Business Sessions. You can proudly wear our SPE button and display your membership certificate in a prominent place. Public recognition was given to the untiring efforts of your national officers and members by the press, prominent professional authorities and the officials of such industry associations as the P.M.M.A. and S.P.I. Our Board of Directors know that my aims for 1950 are high.

Plans are being made to increase our Society's prestige through the activities of the officers, directors, committees, local sections, and last but not least, the consistent effort of each individual member.

We can all do it and be proud of our work. We have come a long way.

We must use the advancement of plastics, knowledge of our materials and methods, coupled with our own experience to attain our 1950 aims.

Our fine, well established membership can succeed.

Your national directors, committee members, sectional officers and members will be best informed as to our success.

Each of you will be proud of your part in this.

Sincerely
C. Todd Clark.

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1950 CONFERENCE HIGHLIGHTS

Left to Right, Front Row: John LaBelle, Marion Arthur, Richard Huber, Wayne Pribble, William Hess; Second Row: E. A. Russell, Stanley Bindman, C. Todd Clark, Mario Petretti, Bess Day; standing: James Growley, Bill Dunnican, Robert Dailey, Richard Bishop, William Bracken, George Clark, Walter Oelman, Islyn Thomas.

The Sixth Annual Technical Conference of the SPE, held at the Carter Hotel in Cleveland from January 11 through 13, was in many respects the most successful conference to date.

First, it was a new kind of conference. There were no exhibits or shows; there was instead a plentiful presentation of technical papers of high quality and first importance. Thirty-nine companies supported the conference by company registrations, and many companies were gratified to support SPE who would not have supported a show. The names of the companies were posted conspicuously, together with the room numbers of their representatives.

The main theme of the conference was the topic of plastics processing machinery. If any one idea was repeated, it was the desire of the industry to develop an injection molding machine to handle present improved materials with shorter molding cycles and improved heating and plasticizing unit.

Especially interesting, and indicative of the considerable progress of the national SPE, were the committee reports read during the Annual Meeting, January 12. The Professional Activities Committee, Quality Control sub-committee and the Education committee reports are scheduled for publication next month.

If one feeling might be said to have predominated, it was the feeling of good-will. The proper fields for SPE activity, and the relationships between SPE and other technical societies and the industry are becoming better defined. In a sense, it might be said that this conference marked the coming of age of SPE.

Harry DuBois and William B. Hoey received the highest honor that SPE can bestow at the Annual Banquet when they received Life Membership certificates from the retiring president, Mario Petretti. Mr. DuBois, widely known throughout the plastics industry for his many publications and for the excellent work he did for SPE during the year of his presidency and before, has long been a moving factor in the growth of SPE. William B. Hoey, of Detroit, was national president in 1945, and in 1946 was the first executive-secretary of the society.

The banquet featured Dr. H. E. Fritz of Goodrich as speaker. The SPE was further honored to have at the speaker's table Dr. D. S. Fredericks, president of P.M.M.A., and Horace Gooch, president of S.P.I., both of whom spoke briefly.

Winners of the SPE Prize Paper Contest were at this time presented with their certificates of award, and checks for the amount of the prizes. The first-prize paper, printed in this issue "The Injection Molding of Derating Materials" was written by Ren Morse of Cleveland and Jerry Stokes of Erie, Pa. D. A. McGraw of Toledo won third prize with his paper "Rheometer Flow Studies of Cellulose Acetate and Cellulose Acetate-Butyrate Molding Compounds." Second prize was taken by William Findley of the University of Illinois for his "The Mechanical Equation of State With Special Attention to Creep of Plastics."

A great stride forward was the publication of all the papers presented at the conference in the SPE Journal. The January issue carried most of the papers, and this issue contains the rest, except for two which depended too largely upon slides for their presentation. In the past we had found most of our best papers printed in other publications, and we are now proud that our members are receiving the complete publications in their own magazine.

More signs of recognition: the British Museum of Science, and the U. S. Patent Office, have both recently requested the SPE Journal for their technical library and files.

Here is the list of the national committees appointed for 1950. If you have any ideas to help them, or wish to take active part on any of them, please write to the chairman, or where his address is not given, directly to the SPE office in Athens, Ohio.

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THE INJECTION MOLDING OF DERATING MATERIALS

By J. C. STOKES
President, Perry Plastics Co., Erie, Penna.

and A. R. MORSE
Sales Engineer, Injection Molders Supply Co., Cleveland, Ohio

First Prize — 1949 SPE Prize Paper Contest

The purpose of this report is to demonstrate a satisfactory solution to the present dilemma of the injection molder who finds that the manufacturer's specifications of his injection molding machine may now vary as much as 50% from actual performance, especially with respect to heater capacity.

Because of the growing importance of de-rating materials, particularly polystyrene, the problem is now acute and requires an immediate and practical solution which can be applied within the limitations of present machines.

To assist in the ultimate standardization of estimates of injection machine capacity, the authors review the numerous problems incident to the design and development of a standard high-capacity heating cylinder which may be readily adapted to various standard machines. From this discussion the authors show how they designed, constructed, and tested a group of four unique heating cylinders specifically built to overcome effectively the de-rating effect exercised by the lighter, more heat-resistant materials on conventional heaters. This paper, therefore, completely outlines the aims and accomplishments of our research and testing.

The project has necessarily been scaled to be one which could be personally financed to avoid any charge of commercial or competitive bias, and the gratifying results are here made public for the benefit of our industry.

RATING INJECTION MACHINE CAPACITIES

The most aggravating of injection machine shortcomings, is the failure to run full capacity shots at today's competitive cycles, using the new high heat-resistant materials. This failure we traced directly to lack of plasticizing capacity or, in other words, the lack of heat transfer ability, in the heating cylinder. Since this lack of plasticizing capacity is the machine fault that causes the molder the most grief, it is the one that the authors decided to try specifically to remedy, with the results as shown later in this paper.

Many other factors have recently contributed to aggravating the seriousness of this growing lack of heater capacity, such as the increase in thin-section high-speed molding, the widespread use of pin point gating, lubricated material, high heat-resistant materials and closely controlled mold temperatures (sometimes to within 2-5°). The growing use of minimum sprues in itself, where the cycle is not slowed by waiting for the sprue to set up, has resulted in a radical decrease in cycle time on many jobs, and an increase in the demands made on the heater.

There are many variables entering into machine ratings which are not strictly in the province of injection machine design and over which the machine manufacturer has practically no control. It is quite apparent, therefore, that no real measure exists for all the variables such as heat, pressure, time, different material characteristics, mold construction, etc., which must be combined in rating the true performance of an injection heating cylinder. Virtually no research has been done on this subject and the topic remains one fraught with controversy and widely varying competitive claims. It must be remembered that the average molding machine must run a couple of dozen or more different jobs in the course of a year and the true measure of the cylinder capacity is the average performance on these varying jobs.

It can be readily concluded from this brief discussion that an attempt to set up standards and tests for rating injection machines is a difficult if not wholly impossible task. The complete absence of standards and the wide variations encountered between manufacturers' claims and specifications, and actual performance led the authors to realize that a heater to overcome the de-rating effect of the newer materials could only be developed on an empirical and not on a strictly theoretical engineering basis. The authors therefore, in an effort to find immediate relief for molders who suddenly found their machine capacities cut in half, set about finding a practical solution to this dilemma by the only possible method. That is, the actual construction of an over-capacity heating cylinder which would fit standard existing machines and which would perform better than the existing heaters using existing materials on a wide variety of tested molds, under a wide variety of molding conditions.

BACKGROUND FACTORS AFFECTING DESIGN OF IDEAL HEATER

Since the construction of a new machine was not contemplated and in as much as most molders have no equipment available for making even minor changes to existing machinery, and since no molder could reasonably be expected to tolerate a costly basic modification of his equipment, it becomes imperative that any improved heating cylinder must fit existing equipment with strict interchangeability and with no required major alteration in the existing machine.

An improved heating cylinder, to solve the problem of the molder in running present day de-rating materials, must have approximately twice the plasticizing capacity of a standard heating cylinder. A simple solution would be to make a heater twice as long as present standard heaters, but one runs into the space limitations of existing machines. Conventional construction prohibits lengthening the heater more than 2¾" in the present instance, and this dimension is even more limited on other machines. It becomes necessary, therefore, to provide adequate heat transfer area (with smooth or long-curving inside construction so designed that the plastic material flowing through will meet with minimum resistance) by increasing the internal diameter of the heater.

Plastic materials can be safely held at an optimum molding temperature, but they cannot be exposed to metal surfacing too much above this temperature without suffering detrimental effects, especially with respect to the physical characteristics such as toughness and brittleness of the material itself and, in some cases, loss of color in the pigments or dyes in the plastic or in loss of plasticizer. On most jobs it is necessary to run closely and individually controlled temperature zones from one end of the heater to the other. At times the temperature of these zones must vary widely from each other.

It was found early in this development that it was impossible to design an ideal heater with due respect for all of the theoretical factors involved and it was therefore necessary to compromise on those of lesser im-

portance in order to make a heater which would fall within the unavoidable limitations of the existing molding machines. Last but not least, the first cost had to be held as low as possible and maintenance cost also must be held to an absolute minimum. Down time to a molder is usually much more costly than the number of dollars involved in making the actual repair to a heater unit. So ease and simplicity of repair were especially sought.

AVOIDING MISTAKES OF PREVIOUS DESIGNS

Many designs of heating cylinders have been constructed and tried. Nearly each one has some good feature, but most also have had some severe limitations. A thorough study of the history of injection machine heaters shows a number of designs and features which should be avoided. Spreader-less heaters have been built, but in general they will not handle a large volume of material. They do overcome the illogical feature wherein cold plastic is forced into the webs of a spreader, but they give no advantage in the realm of a high capacity heater. Some kind of spreader must therefore be furnished.

A long spreader without support will bend regardless of construction. Cold material falls to the bottom of the feed chamber and is forced against the end of the spreader with a greater concentration of material below than above, causing an unbalanced thrust in a vertical direction which tends to bend the end of the spreader. Hence, it becomes necessary to support the spreader at the cold end. Supporting fins are sometimes used, which are lapped to the inside surface of the heating cylinder. In time material is forced between these spreader feet and the surface of the cylinder, with the results that the lodged material burns and discolors, making quick complete color changes impossible and increasing scrap, especially on light colored material. It is obvious that a barrel of steel will expand under pressure more than a solid bar. In view of these troubles with current spreader design, it was deemed necessary to eliminate all lapped or fitted surfaces inside the heater.

Most heaters are constructed by one of two methods. They are assembled into a sleeve from the rear and the load due to the thrust of the ram is taken by internal collars, or by flanges which are held to the cylinder by large bolts. (See Figure 1) The entire thrust load being taken on the bolts tends to stretch them, allowing leakage between the fitted sections which are slipped inside of the sleeve. This condition is further aggravated by the gradual annealling and subsequent stretching of the heater assembly bolts. It is virtually impossible to remove these bolts after

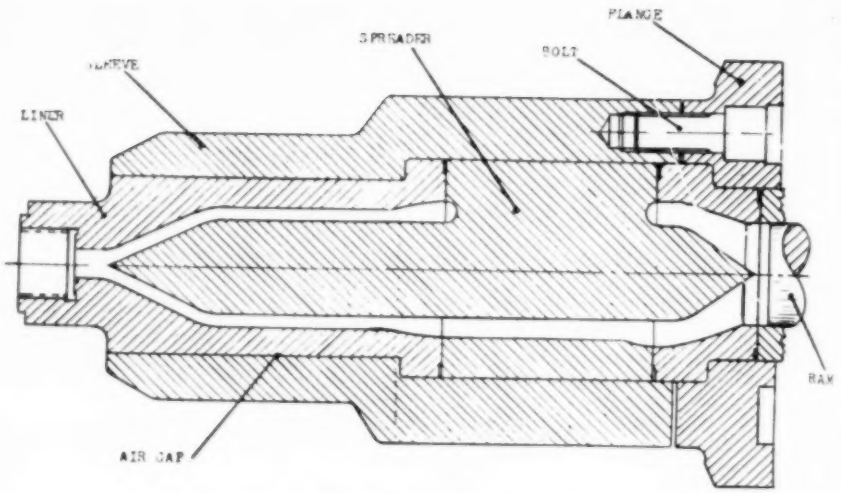


Fig. 1 - A conventional cylinder, showing bolted construction and air gap between liners and sleeve which heat must jump.

the cylinder has been in use except by drilling off the heads. Disassembly therefore becomes a very costly affair.

Some heaters are assembled by inserting the spreader or spreader section from the front into a barrel or sleeve and then screwing or bolting onto the front a plate or nut which takes the full thrust of the plunger. Again this bolt or nut assembly is under direct load from the plunger, straining the threads, often stretching or breaking the bolts, with ensuing leakage which is especially bad since the joint here is at the front or hot end of the heater.

The high maintenance cost of present heaters, therefore, makes some radical departure in fundamental design imperative. This unique and vital step is fully described below. It need only be observed that at this stage that unusual shapes and spreader-less designs were discarded in favor of the conventional type of spreader.

Many heaters have an external step construction and use several diameters or sizes of heater bands. Any such changes in outside diameter of a cylinder cause the applied heat to wander toward the front or rear, out of control, influencing adversely the controlling instruments ahead or behind the source of wandering heat. In the interest of economy, it would be wise to carry in stock only one size and one wattage of heater band. To make this possible it was decided to incorporate a heater wall thickness sufficient to give uniform heat dispersion on the inside of the cylinder (thus avoiding the hot spots found on heaters of too thin wall construction), and then to carry this same outside diameter clear forward to the point where convergence was necessary to clear the taper in the stationary die plate. The aim was to give each pyrometer full control of its own zone without its being affected by floating uncontrolled heat wandering in from adjacent zones, by providing a single outside diameter.

The covers or insulation provided on many heaters have been eliminated largely because of lack of room in conventional machines when the foregoing features are used. Typically, a cover might be provided but the first concern was—and still is—performance, not appearance.

DESIGNING THE HEATING CYLINDER

With the above background, the details of the actual cylinder design were then investigated. Consider Figure 2 where the assembled heating cylinder is shown. Three solid forgings were selected for the three sections of the heating cylinder—the front section, the spreader section, and the rear flange section. The first cylinder was constructed of SAE 4340 steel. This material was selected because of its extreme fatigue resistance, for in this application it is put under extreme fatigue loads, both with respect to temperature and pressure. While no failure has yet occurred on this cylinder, weldability of the 4340 steel was not good, tending to check at the weld. Later it was felt advantageous to change to SAE 4130. This was in the nature of a compromise, as it is a material having high fatigue resistance, good heat treating properties, and excellent weldability for a material of this series.

To avoid assembly and disassembly problems previously mentioned a revolutionary all-welded construction was selected, and details are here disclosed for the first time. In assembly the three elements are carefully fitted together and are preloaded axially in a hydraulic press at 150 tons while the welding is done from opposite sides simultaneously to avoid distortion. The details of the welded joint were carefully planned. A turned shoulder serves two purposes. It takes

most of the sidewards or bursting load so that the weld is called upon to take only the axial tension load. Also during welding, it prevents misalignment or distortion of the members, thus minimizing the danger of a poor seal between the elements of the heater, and eliminating the "steps" sometimes seen inside other heaters, where an outer body is used to align the internal members, and lack of concentricity can more easily occur.

If "burning" or "eating" should eventually occur at the joints, or seals, repair can be readily accomplished by the simple expedient of turning out the weld, refacing the joints, and rewelding the assembly. The expense of this operation is far less than that incurred in reworking an ordinary cylinder. In a typical eight ounce cylinder specifically the average repair has been found to be in the neighborhood of $500. In the present unit, complete overhaul approximates $250 or less, and can be accomplished in a few hours. The elimination of any bolted or threaded construction has proven to be a practical solution to this part of the problem.

It is noted that there is a complete absence of sleeves and liners or any other such type of overlapping construction. This simplified design was chosen for several reasons. Where the sleeve and liner type construction exists, the parts must be loose enough so that they can be readily lapped and assembled. These parts being of varying sections, expand and contract at different rates so that no consistent picture of the stresses on the various members of the supported construction can be drawn. The intermittent stretching of the bolts or nuts of the threaded assembly as injection pressure is applied and released is a bad enough feature, but the chief reason of abandoning the sleeve and liner type construction is to eliminate the air gap between the inner and outer members which causes a demonstrable heat transmission loss approaching 20%!

In an effort to plasticize the new high heat resistant materials at a rate sufficient to give maximum shots at optimum cycles, it is often necessary to run standard cylinder temperatures in the neighborhood of 650° F. to well over 700° F. with the resultant danger of overheating the outside layer of material where it is in contact with the superheated cylinder and failure to plasticize properly the material in the inside of the layer flowing through the heating cylinder. This results in poor physical characteristics, poor flow characteristics, and often in discoloration due to poor mixing and uneven melting of the material being molded. The quantity of heat transfer from one surface to another is dependent upon the area involved, the difference in temperature between the two surfaces, the length of exposure time involved, and the specific heats of the two materials in contact. It is obvious that since the cycle time must be held to a minimum due to the terrific competition facing the molder, and since the temperature difference cannot be too great lest the material be burned on the surface, and since the specific heats cannot be altered, the only variable which can practically be changed to improve a cylinder's capacity to transfer heat (or, in other words, to plasticize material) is the contact area involved.

The cylinder was therefore lengthened as much as was possible (2¾") and still kept within the confines of the existing machines upon which the cylinder was to be used. In particular, length was added to the column of material ahead of the spreader by moving the spreader webs as far forward as possible. This still did not give as much heat transfer area as we felt was needed. It was necessary therefore to increase greatly the inside diameter of the cylinder as shown and similarly increase the outside diameter of the spreader. However, sufficient wall thickness was maintained so that, with the lack of conventional steps (except where necessary for convergence at the front end to clear the fixed platen), any localized heating effect was eliminated, even though the volume of material inside the heater was more than doubled.

DESIGNING THE SPREADER

The spreader illustrated in Figure 2 has been chosen only after a long investigation of proposed designs. The markedly lengthened taper at the ends gives superior streamlining, and makes for less resistance to the cold, hard, compacted material directly ahead of the plunger. The webs are located farther forward as previously mentioned and farther away from the end of the plunger to allow the material time to begin to soften somewhat before striking them. This minimizes the danger of cracking the webs of the spreader which is the most common form of trouble encountered in conventional heaters of this type.

The question of heating the spreader by the use of a cartridge heater was considered but was discarded because of the maintenance angle, plus the fact that the heater cartridge which could be introduced was of relatively little importance compared to the total wattage applied (11,500 watts). If the integral webs supporting the spreader are of the correct size, sufficient heat will be carried through them into the spreader to raise the temperature of the entire spreader to nearly the surface temperature of the inside diameter of the cylinder itself. The size and number of the holes, the shape of the exit, and more particularly the streamlining of the entrance, and the length of web, all have a definite bearing on the ability of the spreader to transfer heat at a satisfactory rate, and these details are not yet released for publication. We found that internal heater and spreader design was the key to the problem, and not a marginal move like heating the spreader.

In order to speed the flow of heat from the region of the webs axially to the extreme ends of the spreader, copper or sodium or mercury inserts inside the spreader were also considered. Investigation revealed that the gap caused by drilling for the insert almost exactly offset the gain in conductivity so achieved, while the differential expansion rate of the unlike materials complicated the final engineering of the spreader by introducing a possible cause of failure across the webs. Since the increase in plasticizing rate was already accomplished by other means, particularly by an increase in heater volume, it was felt that the small, even dub-

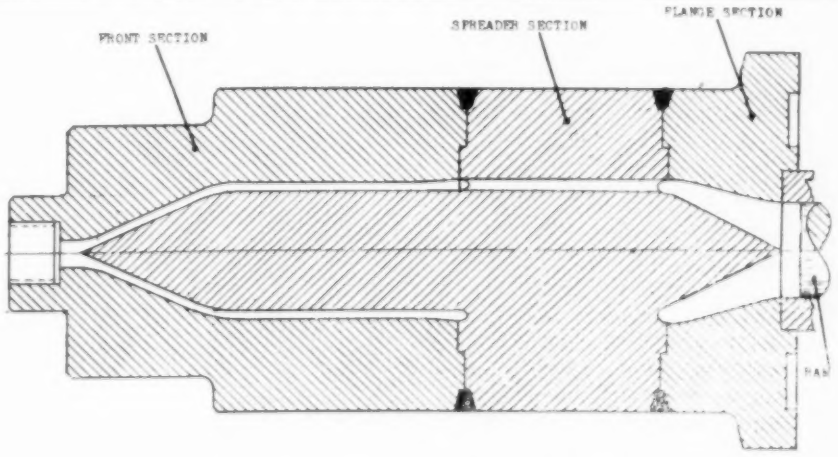


Fig. 2 - New Cylinder, showing welded construction, improved spreader, and greater heat transfer area.

ious, gain to be made by tampering with the spreader was more than offset by the maintenance cost factor in this instance, and the solid spreader was adopted.

HEATING THE CYLINDER

Cylinders have been heated variously in the past by gas, steam, hot oil, low frequency induction, and electric resistance heaters. Of all these types, the electric resistance heater has generally been found most satisfactory. It is not necessary to go into the advantages and disadvantages of this type of heater. Powder packed bands were chosen, in spite of their higher cost, because they have a life advantage over mica insulated types. Also, this kind of brand is most readily replaced in emergencies from present parts stocks in most molders' plants. For these many reasons, a standard well-proven 1200 watt band was selected, but with one important change.

It was discovered that most bands heated an arc comprising only about 65% of the circumference of the heater because of the cold ends necessitated by the clamping device and spacing of the terminals. By using a slightly different type of clamping arrangement but an entirely standard band, it is now possible to heat approximately 85% of the circumference of the heater, eliminating what is a considerable cold spot in many present heating cylinders.

No other heat sources, such as an internally heated spreader were considered satisfactory enough from a maintenance and construction viewpoint to merit inclusion in the design. Conventional flange and nozzle heaters were used because, having accomplished the aim of achieving sufficient plasticizing within the heater body, the refinement of these minor features seemed unnecessary and, furthermore, these bands can be readily replaced from most molders' existing parts inventory.

(Ideally, the cylinder should be grooved to receive triangular calrod type heating units, possibly with the whole encased in a tight fitting one piece copper jacket to insure greater conductivity from the source of heat to the steel walls of the cylinder itself. This added refinement was considered, but was discarded because of the lack of existing replacement parts, and the disproportion between the initial cost and benefits gained.)

TESTING THE PILOT MODEL OF THE HEATER

As discussed in the opening paragraphs of this paper, it was obvious that no measure of heater performance was available due to the absence of agreed standards, except actual results in full competition with existing equipment. All of the results discussed in these following paragraphs were observed in running the pilot model heating cylinder on a variety of molds which had already been run on standard factory equipment.

The results discovered after the construction of the first heater showed that much lower cylinder temperatures could be used. This indicated that marked improvement had been made in the rate of heat transfer. To put it another way, a greater amount of material could be plasticized with lower cylinder temperatures (but not necessarily with lower quantity of heat input). The control instruments were "on" about 20% less than with a conventional heater. The tendency to over—and under—shoot the set heat was almost completely eliminated so that even with standard "off-on" pyrometers, exactingly close control of heater temperature was achieved. A temperature differential of as much as 50° could be set and maintained between the front and the rear zones.

Color changes were readily and quickly made. It was now much easier to flush out one material in changing to another. A steadier rate of injection plunger travel was noticed, making the rate of cavity filling much more constant and rapid, since the plunger did not hesitate when it struck the new cold material and began to push it into the spreader zone.

Specimens of material taken from the spreader seen in Figure 3, prove that (unlike conventional heaters), the material in this cylinder has started to plasticize well before it enters the spreader zone.

In running a stubborn refrigerator dish mold (typical of the de-rating jobs facing the injection molder), which had previously run three cavities weighing six ounces with 18% scrap on a cycle of 36 seconds, the new cylinder ran four cavities weighing eight ounces with 1½% scrap on a cycle of 32 seconds. Previous cylinder temperatures had been 625° F. New cylinder temperatures were 550° F. The net increase in production from this job was slightly over 50% over a 5 month test period. This was truly phenomenal performance. An intangible but very desirable gain was a noticeable improvement in physical characteristics (toughness) of the molded part. Improvement in production rates was also found on every other mold tried, even those whose shot weight was as low as two ounces. The average increase in performance of **all** molds excepting the special thin-section case noted above, was between 10% and 12%; on no mold was it under 3%. On no part was there a lack of improvement in physical characteristics, due to more gradual heating of the plastic, and to the absence of overheating in the new cylinder.

This kind of performance means great savings for the molder. This is the kind of evidence which was sought, particularly as pertained to molding a thin section container at high speed where plasticizing was the limiting factor, and we felt we had found a practical approach to the problem of de-rating materials.

Plating of the internal heater parts was not done to observe the detrimental effects—if any—of the omission. It was believed that some other material like Z-Nickel or hastelloy would be more suitable for highly corrosive materials. The lower ambient temperatures achieved, the close proximity of the thermocouple control points to the material itself, and the quick response of the molding powder in the melted state to the demands of the controlling instruments all suggest that the so-called "throwing of iron marks" can be avoided without plating.

After running the pilot model for eight months under severe operating conditions with no failure of any kind, it was given deliberate and terrific abuse for a two weeks period including 20% overload pressures against a clogged nozzle with overheated and extremely fluid material in the cylinder; pushing cold, hard material against the spreader fins under 20% overload pressures before the material had time to soften, etc. The cylinder was then cut apart to observe the effects of its tests up to this time. No indication of any structural failure or of corrosion was found.

As was observed above the plastic material starts to soften well before it reaches the fins of the spreader and is completely plasticized by the time it passes through the openings in the spreader.

Figure 3 illustrates samples taken from the webs of the spreader. It also shows the plasticized material taken from the front section of the cylinder. Note the large volume of melted material held in storage—approximately twice that found in ordinary heaters, or 8 to 10 full capacity shots.

Opportunities for minor improvement in streamlining were found after examining of the parts shown in Figure 3 and the entire cylinder was repolished, the streamlining improved, and it was rewelded together. In the time that it has been running since, it has been observed that a further reduction of four or five percent in pressure is now possible in pushing material through the cylinder.

—CONCLUSION—
TESTING A PRODUCTION LOT OF HEATERS

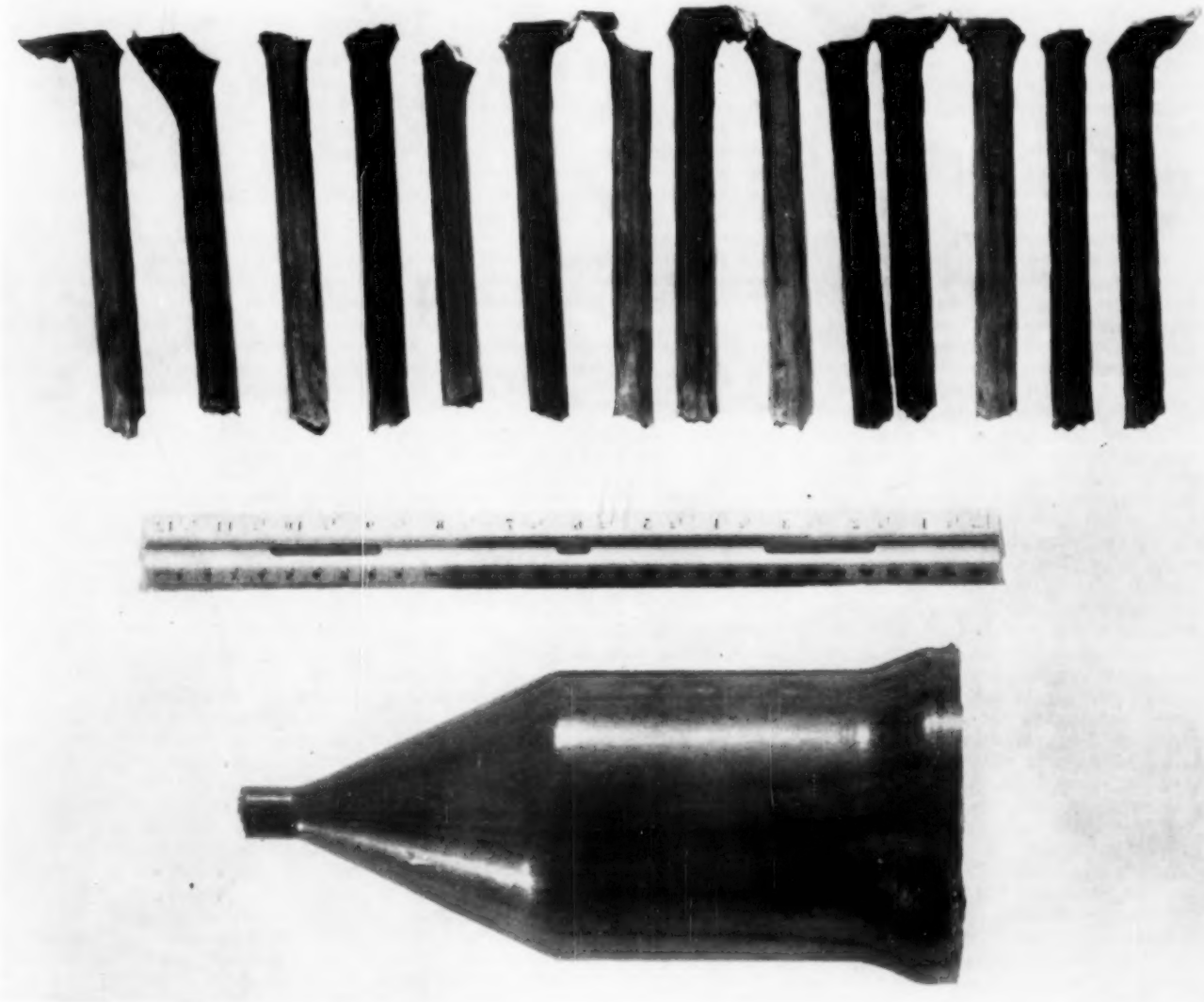
A long-term problem of tremendous importance remained. Would color changes continue to be easily and readily made? Would it be possible over a long period of time to change back and forth to unlike materials? Would the heater stand up structurally over long periods of time? Would the welding be entirely satis-

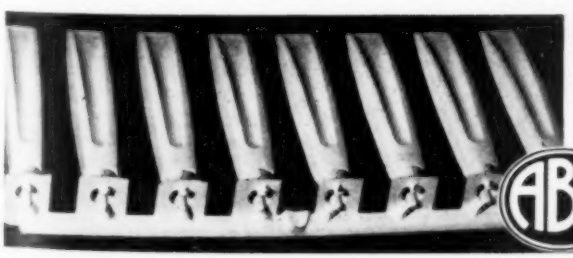
factory? Would the maintenance costs be drastically reduced as has been hoped? Would the marked benefits on de-rating materials and oversized jobs which tax not the molding but the plasticizing capacity of the heater, be confirmed by other molders?

To secure the answer to these imponderables and yet remain within the scope of the personal financing ability which had freed the authors from commercial prejudices and the limitations of traditional engineering thinking, it was decided to construct a group of three more heaters to be placed in representative shops with an unconditional guarantee. The shops were selected because of the specialized and advanced type of molding performed.

In general, three types of work were recognized for this purpose. (1) High speed, thin-section styrene work where de-rating has been a particular complaint in the race to produce containers which can compete in cost and toughness with wood and paper. (2) Acetate-styrene molding where molds were designed to be used on both materials, and where a lower heater temperature would give a major reduction in cycle because of the large sprue, runner, and gate sizes involved in the interchangability. And (3) miscellaneous molding including most especially the acrylics, polyethylene, and the vinyls in that relative order of importance.

Accordingly, three additional heaters were manufactured and put under the indicated conditions of test, where performance has met all expectations outlined in the foregoing paper. Plans for manufacture and distribution and service of additional units to overcome de-rating have been completed, and these overcapacity heaters are now commercially available without alteration for a large number of standard machines.





Intricate Molds? The mold for the brush handles shown at the left *(courtesy Fuller Brush Company)* required not only intricate design, but ultra-smooth finish to meet today's mass production needs. Our sound engineering experience and modern equipment and methods are the answer. *WRITE FOR LITERATURE.*

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INFORMATIVE LABELING

By P. A. BELK

Hercules Powder Co.,
Wilmington, Delaware

When you do hitch your product to a label, you get three immediate benefits. First of all, you get a twenty-four-hour day salesman who goes right along with your product from the time it leaves the factory until the consumer takes it home, and it is doing a selling job every step of the way. When you hitch your product to a label, you insure yourself that your ultimate customer is going to get the best possible results from that product. He will use your product right and it will serve him well and it will thus enhance your reputation as a manufacturer. When you hitch your product to a label, you eliminate misuses and accidents, and as a result, you minimize complaints and reduce returns and adjustments. When you hitch your product to a label, you get all these tangible benefits and you get one other benefit besides. You tell the great American consumer the truth about plastics, and, thus, you help not only yourself, but the entire industry.

In many industries, competitive products are almost identical, production techniques are similar, and financial structures differ very little. In many cases, the only difference between success and failure in business hinges upon the skill of a company's sales force. In our own plastics industry, we have a good example of what sales ability can do. Many a custom molder has been able to survive the difficult postwar period only because he was merchandising conscious and was able to supplement his custom business with a proprietary line of products which he not only knew how to make but also how to market.

One of the busiest and hardest working salesmen on any manufacturer's staff is the informative label that goes out with his product. This label sticks with the product as it travels from the factory to the store and ultimately into the hands of the consumer who will put it to use. It can make important sales contributions all along the line. It tells the wholesaler what he is buying from the manufacturer, and it helps the retailer's clerks to tell the customer what is being sold. And when the consumer buys a product, it serves as a reminder of all the features he may have heard about while he was making the purchase but has perhaps forgotten by the time he gets the product home.

Labels can be loosely classified into two groups. The oldest and best known type of label is the identification label. A good example of this is the three-letter sign over the men's room. Such labels as we all know can be very important and helpful. Sometimes the identifying label is accompanied by a symbol such as the cross we often see on the door of a dispensary or first aid room. This combination of identification label and symbol—or trade-mark—has long been an established part of our lives. The informative label includes the elements of the identification label and provides added information of value. The sign on the little door inside the men's room that says "INSERT 5c AND TURN KNOB TO THE RIGHT, TO INSURE PRIVACY DO NOT TURN INSIDE LATCH UNTIL READY TO LEAVE," is a good example of an informative label at work. In other words, the informative label, in addition to identifying the product by giving its name and the trade-mark of the maker, also supplies pertinent information which will enable the product to be put to its proper use. In a sense, the term label when used in this connection is not completely accurate. We only use it for lack of a better term. The use information supplied on a so-called label may be conveyed in a number of ways: it may, for example, be in the form of a hang tag attached by a piece of string to the product. Perhaps it may be a wrapper or band bearing the required imprint. Sometimes it appears as a pin ticket or a sales card or even an elaborate instruction manual. For example, the large booklet which is usually found in the glove compartment of a new car and serves to acquaint the owner with every important factor from bumper to bumper is actually nothing more than an elaborate type of informative labeling. Most customers have come to look for and expect to find an informative label of one type or another on most of the products they buy. One of the most amazing things about this business of informative labeling is that until recently the plastics industry — which perhaps needed an informative label more than any other industry, simply because it was selling materials that were comparatively new—was the industry making least use of this important and helpful selling device.

We like to make ourselves believe that by now plastics materials are not only established but accepted and understood. However, that is far from the case. There is a whole army of American consumers — millions of them — who do not know one plastic from another. When they have something made of plastic which is doing a good job, they don't know how to ask for other products made with the same material. When they have a plastic product that fails, they blame the whole collective family of plastics for the failure. When a consumer buys a glass dish and he drops it and it breaks, he blames himself for his clumsiness, shrugs, and buys another one. When he puts a plastic plate on the stove and it burns, the customer burns too. That is why we hear people in every branch of the industry saying that we have to educate the consumer about plastics. However, not too many people are taking any steps towards launching this educational program that everyone admits is needed.

For a number of years, the SPI has studied methods and means for satisfying this critical need for consumer information on plastics. Many different approaches to the problem have been tried. By now it has become apparent that the quickest and most effective means of getting the key information to the spot where it is most needed—the point of sale and when the product reaches the hand of the consumer—is through the informative label. Informative labeling is not something to put on the agenda for future consideration. Informative labeling in plastics is here right now. Many manufacturers are already using it to stimulate and expand sales. Informative labeling has been the secret of the fast-growing housewares market for plastics. Informative labeling is responsible for the successful merchandising of vinyl films. But for every plastics manufacturer who is now using a label, there are a dozen manufacturers who have not yet gotten around to labeling and as a result are to some degree hampering the effectiveness of those sincere persons who are already trying to bring to the consumer this key information on plastics which he sorely needs and wants.

Let's look for a minute about what happens when a manufacturer decides to put an informative label on his products. First of all, he has to decide what he is going to say. What can he tell the user about his product

that will be of most value? What are the weaknesses of the product? What are its good features? How can the consumer handle it to insure getting full value for his purchasing dollar? To find the answer to these questions, the manufacturer must carefully analyze his product. When he starts to do so, not just the sales force but very often the engineer and the production man quickly enter into the picture. Analyzing one's product is something like trying to analyze one's self. The experience can be startling. Many a manufacturer has discovered when he sat down to outline what he was going to say on his informative label that there were a lot of things he could do with his product that would make it a better one. Sometimes he has found that by making a change here and there he might be able to sell a product that would qualify for approval by one of the many groups who have set up standards for various lines. Sometimes he has found his product is far superior to others in the same field but that there was no standard for judging his product against his competitors so that he immediately sets out to find some means for establishing a standard that will enable the consumer to recognize his product as one of superior value. The very moment that a manufacturer takes his first step of product analysis in connection with the planning of a label, he starts a whole chain of activities. Though many engineers might look upon labeling as purely an advertising and sales function, it will be found that as the informative labeling becomes standard practice in the plastics industry that they will play an important part both in the preparation of the label itself and in the engineering of the product to make it qualified for the best type of label possible.

What progress has been made since the SPI first formed a labeling committee well over a year ago? The first report of this committee was made at the annual meeting in Chicago last June. Since that time, the major committee has been hard at work with the preparation of a handbook on labeling which would serve as a guide for the entire industry. To expedite this job, three sub-committees dealing with promotion, terminology, and market research have been formed.

Many of the initial problems which were encountered have already been ironed out. It soon became apparent that the big problem which must be solved before a handbook could be successfully prepared was one of reaching an agreement on a terminology and definition of the many plastics materials now being marketed. A questionnaire was sent out to the industry to ascertain the extent of the use of informative labeling at this time. Over one-third of those answering the SPI questionnaire reported that they are now using informative labeling on some or all of their products. When asked what they needed to help them in embarking on an informative labeling program, the things they mentioned in the order of their importance as indicated by the questionnaire were as follows:

(1) Suggestions and help from SPI and a consolidated and uniform guide for their individual programs.

(2) Assistance and labels from material suppliers.

(3) Uniform terminology — a simple means of describing their products.

(4) A cheap, fast method of attaching labels.

(5) Advertising and promotion support of labeling by the SPI.

All of these things are available now or are on the way, but what is needed most of all is the interest and cooperation of personnel on every level of the plastics industry. There is every reason to believe that a handbook on labeling will be available within a very few months, but the time to start labeling is now, and if a manufacturer or molder needs help with specific labeling problems and cannot get it through such regular channels as his advertising agency, package designer, or printer, a working committee which is a part of the regular SPI committee stands ready to help.

Send us in your problems and let's see what we can work out.

A NEW INJECTION MACHINE

By JAMES W. HENDRY
Jackson and Church Co., Saginaw, Michigan

Although the principal of shooting pre-plasticized material into a cavity is not new, most of us have wondered about the best way to approach the problem. To date we have been satisfied with existing machines, and as a matter of fact, the market has not demanded a new machine until the past year and one-half.

With competitive prices coming in however, and faster cycles required, with steel putting up the battle of its life for its existence, we must look for machines to cut the cost of injection molding down to a bare minimum. Cycles cannot be fast enough; they can only be too slow. If the time required to inject material into a mold is two seconds, it is exactly two seconds too long.

The injection time is a necessary evil. The time to plasticize the material is a necessary evil. The only thing that is not an evil is the time required to cool the part in the mold. That is the part's own fault and not the fault of the machine nor the material to be injected. Therefore, we must design a machine that will best suit the industry and eliminate all possible chances of having the mold wait for the plasticizing member of the machine.

With this objective, and before designing our proposed machine, it is wise to see how other industries have approached similar problems. In the rubber industry for instance, when they are mixing material, they do not mix through a torpedo or through any straight shot cylinder; they mix in a Banbury Mixer that mulls, chews and properly and uniformly mixes. Therefore, we find that a **variation** of a common extruder is the most efficient method at present on the market.

There are many other methods of mulling and mixing material, getting it uniform and getting it into a state where it could be injection molded at very low pressure but, are they economical? For example, a specially designed double screw will plasticize material completely and uniformly. This is better than a single screw of conventional design; the mixing happening in this single screw is very little. However, costs are high. The pounds per hour on a straight screw is determined by the capacity of the machine plus the length of the extruder. A common extruder of approximately 3½" diameter, running with a standard screw at a speed of 40 R.P.M. should deliver about 80 to 90 pounds per hour in polystyrene. The length of this screw will be approximately 3½ feet. In a standard injection molding machine with no mix at all, capable, so we are told, of plasticizing 100 lbs. per hour, the cylinder is approximately 24" long. The barrel on this should be approximately 3½ feet long to get the same results that a single screw of conventional design gives. Therefore, to pre-plasticize material or get it up to a viscous flow state where it will be easily injected into the mold, the machine should thoroughly mix the material, move it, break it down and bring each particle to the same temperature before putting it into an injection chamber. This is the ultimate. We cannot do it with an injection chamber nor can we do it with a

single screw of conventional design. While thinking of this general design, let us for a moment look at the possibilities of a single screw specially designed that can mix, mull and uniformly heat each granule of plastic.

Just what else could this unit do besides uniformly heat material? If it could mix thoroughly, **it could color materials.** If it could mull thoroughly, **it could compound materials,**—two very important things in the plastic industry coming up in the near future. For example, a molder has a job that does not look too attractive to him, yet the quantity looks very attractive. The job isn't attractive because the job demands eight different colors in polystyrene. To change over from one color to another is expensive not only because of the material lost in purging the machine, but from the standpoint of inventory: the amount of material that must be kept on hand and the cost of these materials in buying in small quantities. This would indeed make any job unattractive to molders. Now, if we have a unit that will color this material satisfactorily, we could buy an all crystal material such as crystal styrene or crystal acrylic. We would keep on our shelves many different dyes and when we needed a thousand pounds of red, we would pull out a thousand pounds of crystal, a given amount of dye or pigment, mix in a tumble mixer and put it directly into the hopper of the machine. When it is propelled through this specially designed compounder screw, it would come out the other end perfectly colored, plasticized and ready to mold.

A 3½ inch screw gives approximately 80 to 90 pounds per hour **conventional design,** at approximately 40 R.P.M. This is too slow for a 48 oz. machine. If the extruder is speeded to approximately 200 R.P.M. the output per hour on a specially designed screw built on the surge principle of continuous operation will thoroughly **color 285 lbs. per hour in polystyrene** and heat or get in a viscous flow state, 360 lbs. per hour. This is a great savings in material cost. Crystal styrene is approximately $.05 per lb. cheaper than colored stock purchased from the material manufacturer. But who is to tell the molder how much die or how much pigment to put in the crystal material, and how long should it be tumbled? The molder can call upon the material manufacturer for this information and, I am sure, that they would gladly recommend, work and strive to give this information correctly.

The molder could purchase the base flake or resin; then buy stabilizer, plasticizer, filler and pigment. This is stock on hand. The molder then could pre-mix them, dry in the case of acetate and ethocell, and tumble these carefully and accurately and feed them into the machine. With this specially designed unit the material goes through this unit and comes out the other end perfectly compounded.

In the case of vinyls, wet plasticizers are used, and it would probably take a Day Mixer thoroughly to mix the wet plasticizer into the material. This reduction in cost of compounding one's own materials directly in the machine would mean a great saving. One could save with this unit approximately $0.04 to $.07 per pound in the vinyls, ethocell and acetate. Again the question, "who is to tell us how much to put in these various batches?" arises. Again the material manufacturers must tell how much to put in these various units. Whether base acetate flakes would ever be for sale from materials manufacturers is not known, **but** with a specially designed unit this can be accomplished and inventory is kept down.

This eliminates compounding the material in a compounding room, pelletizing it and putting it away in stock. This way one can heat the material once and inject it completely plasticized and compounded into the cavity proper. This is a tremendous saving in material cost alone.

INJECTION CHAMBER

The torpedo isn't needed anymore, it was just a necessary evil, which can now be replaced by a straight shot cylinder. The material is propelled very rapidly from the pre-plasticizing unit into this injection chamber, and then the ram is actuated. The injection pressures will be extremely low for polystyrene—approximately 3,200 lbs. per square inch on most injection jobs. We find that going through the nozzle, and after extensive checking, that the pressure drop is approximately 2 to 1. This is quite a phenomenal discovery. Further, by shooting under these low pressures one can use more square inches of projected area per ton clamping pressure. We find that one ton per square inch is sufficient clamping pressure when using preplasticized material and shooting down to the parting line of the mold proper. This means that a press with 500 ton clamping pressure should give 500 square inches projected area on most styrene parts. However, we cannot say that viscosity plus speed will not flash a mold. Therefore, temperature control is important, also wall thickness is important; and this leads us into our next point.

MOLD DESIGN ON LARGE PROJECTED AREAS

Mold designers all over the country are aware of this fact: that molding into a larger cross section increases the distance of flow and pressure is not built up until the extreme edges of the cavity are filled. However, going through a thirty thousandths thin sheet completely to the end is just like trying to blow through a restricted gate. The material will set up or it will take a great deal of pressure to get it to the outer edges or the **mold must run very hot;** therefore, mold designing is a very important factor in shooting either on a conventional machine or on a preplasticizing piece of equipment.

ANOTHER ADVANTAGE

Shooting at these low pressures, the molded piece is more free of the strain in the piece which leads to breaking or warping. That means better moldings.

RESULTS

We have been, up till now, discussing what would happen when shooting pre-plasticized material. Now we are ready to say that these are facts. They have been done and they have been proven. Let us sum up exactly what has happened about the solution to the problem of keeping the machine ahead of the molds, along with the saving in material, etc., and see exactly what has been accomplished by using a new type of pre-plasticized unit.

1. We have made the mold the limiting feature. In other words, when the part is ready to be ejected from the mold, the next shot is ready to be injected in. There is no wait for the injection chamber to plasticize the next shot. The limiting factor on a Extruder Pump Pre-Plasticizing Machine using the mulling, compounding action, either with a screw or some other method of special design, has eliminated the press as the deciding element in the time cycle. This results in faster cycles.

2. More strain-free moldings and better parts result in the **quality** the purchasing agent has been looking for—a better product.

3. We have cut down material cost. By being able to color—by being able to compound. This means less inventory on hand—cheaper inventory on hand—not a bit less quality on hand and we have cut down the initial cost of the machine proper. This is a big saving to the molder on the initial outlay in money. Granted, the cost of the machine is not as important a feature as in the "trouble free" running, its maintenance cutting features.

Therefore, we have saved many things on the machine proper in making a pre-plasticizing machine.

These things will be a definite advantage to the industry itself and will help tremendously to wake up the other machinery manufacturers to the fact that the honeymoon is over. Whether or not we have the complete answer to the pre-plasticizing principle, we do not know, but we do believe that it is a definite step in the right direction and we will go on record as saying all large equipment in the very near future will have to depend on the pre-plasticizing principles or the machinery manufacturers in general, on a 60 oz. machine will have to have an 8 foot injection cham-

(Please turn to page 21)

LOW MOLECULAR WEIGHT POLYETHYLENE RESINS

By C. W. PATTON

Bakelite Division of
Union Carbide and Carbon Corp.

The history of polyethylene, when compared to other themoplastic materials, is a very short one. An interesting sidelight to this history is the fact that both manufacturers and users of polyethylene are giving added concrete proof of the resourcefulness and drive of American industry.

By now it is well known that ethylene resins were placed in large scale production during the last war under conditions of extreme urgency and for a very specialized end use; namely, insulation for radar equipment. The emergency of the procedure produced a situation almost the reverse of the normal commercial procedure which dictates long periods of exploration of processes and investigation of end-uses before launching full scale production. At the war's end industry had available relatively large quantities of a new and extremely interesting material but relatively little background on its utilization. That industry moved swiftly despite the latter handicap is evidenced by the post-war shortage of polyethylene. Producers moved with equal alacrity because total production had climbed to about 15,000,000 pounds in 1948 and in 1949 productive capacity jumped to the neighborhood of 50,000,000 pounds —an increase of more than three-fold. In addition, manufacturers faced the difficulty of designing and obtaining the costly higher pressure equipment needed for large scale production.

Prices per pound of polyethylene resins have gone equally fast or faster in the opposite direction—from the one dollar per pound range to the present low of 44 cents per pound for certain grades in carload lots. Those associated with the use of polyethylene resins are practically unanimous in predicting a continued rapid growth, and even more important, they are backing up their predictions with expenditures of man-power and money to expand present operations and to enter into new fields.

Low molecular weight polyethylene resins have developed in a more normal manner: first, the experimental production of various molecular weights, then development of compounding and other application processes, followed by commercial production of the materials and the inevitable lowering of prices. This latter appears particularly important in the use of the low molecular weight polyethylene resins in paraffin wax mixtures for coating paper for such prosaic, but large volume, items as bread, and frozen food wrappers.

Before going into greater detail on applications of these materials, it may be well to more clearly define the term "low molecular weight" polyethylene. Ethylene can be polymerized under various conditions of time, temperature, high pressure, and catalyst concentration, to give end-products covering a range of average molecular weights from the hundreds upwards of 20,000.

The properties of these various polymers vary from oily and grease-like materials in the 500-1,000 molecular weight range to wax-like materials in the 4,000 molecular weight range, to soft resinous substance in the 7,000 range, and to plastic-like substances in the 10,000 and up molecular range.

The softening temperatures (as measured by the transparent point) range from 37.5 deg. C for 1,000 molecular weight up to 110 deg. C. and up for the 21,000 and higher polymers.

Viscosities at 130 deg. C increase rapidly as we proceed up the molecular weight range from 0.4 poises at 1,000 molecular weight to 1 x 10^6 poises at 21,000 molecular weight.

Tensile strengths increase from 615 at 7,000 molecular weight to 3,000 pounds per square inch at 38,000 molecular weight. Percent elongation from 40 per cent at 7,000 molecular weight to 625 per cent at 38,000 molecular weight.

The brittleness, as measured by modified ASTM Method D-746-414, goes from 50 per cent of the 7,000 molecular weight samples not breaking at minus 16 deg. C. (3 deg. F) to 50 per cent of the 19,000 molecular weight samples not breaking at minus 90 deg. C. (minus 130 deg. F.)

The brittleness index of 50 percent passage at minus 16 deg. C. for the 7,000 molecular weight material, while a good relative figure for comparison with the other molecular weights, and while suitable for plastics work involving relatively thick sections, cannot be transposed directly to indicate utility, or rather lack of it, at low temperatures, of thin coatings on paper. Actually, thin films on paper will withstand considerable mechanical abuse at sub-zero temperatures.

Many other useful properties, such as chemical resistance, moisture-vapor transmission resistance, flexibility, and certain electrical properties do not vary widely over a relatively wide range of molecular weights.

The designation of certain ranges of molecular weights as high, medium and low is highly arbitrary. Present custom is to call molecular weights, in the 15,000-and-down range "low", the 24,000-and-up, "high", and those between are as a result called "medium".

The relatively narrow "softening range" and low viscosity of the low molecular weight polyethylene resins have made their use in potting compounds highly advantageous. At elevated temperatures and with relatively slight pressure, the resin can be made to flow into and around compact, intricate electrical assemblies, and windings. Potential coils for use in electrical watt-hour meters are admirably protected in this manner. The combination coating-impregnant withstands a 15 kilovolt breakdown voltage and continuous aging over temperature cycles from minus 40 deg. C to 100 deg. C. Without further elaboration, suffice it to say that the simplicity and efficacy of this type of application should suggest to the plastics engineer a wide range of related applications in industry.

Just recently one company developed a small manually operated device which is clamped on to an injection mold to force molten low molecular weight polyethylene into it. Thus, a check on finish as well as dimensions of a new mold can be made without having to set it up and make a test run.

Low molecular weight polyethylenes, as well as the higher ones, have a high degree of chemical inertness. In fact, it is difficult to find materials which will adhere to them. This property is contributing to a new word "Abhesive" meaning the opposite of "adhesive". Low molecular weight polyethylene coatings on paper and cloth are effective interlayers in adhesive tapes and slabs of rubber compounds, to prevent adhesion of successive layers of the products involved.

The so-called "abhesive" qualities of low molecular weight ethylene resins have led to investigation of their use in small percentages in other plastic calendering, molding, and extrusion compounds as lubricants and mold-release agents. Possibly specific examples of such use will be available later on.

The chemical resistance of ethylene resins has naturally led to much work on their use as coatings for chemical and processing equipment. However, the fact that these materials are essentially soluble only in hot sol-

vents has necessitated their application to metal equipment by such methods as flame-spraying. In this method the material is applied in powdered form, similar to the technique used for spraying powdered metals. Recent results indicate the lower melting point of the lower molecular weight (12,000) polyethylene resin facilitates the fluxing of the powder on the metal surface to give a continuous coating.

Undoubtedly, the greatest single field of applications for the low molecular weight polyethylene resins at present is in the packaging industry, principally food. Small percentages (2 to 15 per cent) added to paraffin wax used in coating paper for bread wrappers produce the following desired results:

1. Less penetration into the base paper, hence greater coverage per pound of coating;
2. Increased strength of the heat-sealed bonds that keep the wrapper in place;
3. Better gloss, hence better sales appeal;
4. Improved low temperature flexibility which gives resistance to flaking in cold weather;
5. Resistance to rub-off both in bakeries and stores, and in the hands of the consumer;
6. Improved moisture-vapor transmission resistance after the wrapper is folded, necessary of course, in wrapping the loaf.
7. Less tendency of coated paper sheets or rolls to stick together after coating and prior to wrapping around the bread, this property of low molecular weight polyethylene resins is particularly desirable in warm weather.

All these foregoing advantages are obtained in addition to the basic qualities of paraffin wax which have led to its widespread use over the years. There is some evidence that moisture-vapor-transmission resistance of the polyethylene-fortified wax is dependent upon methods of compounding and coating. Another factor to be considered is that the addition of low molecular weight polyethylene resin obviously causes a substantial increase in the viscosity of the molten paraffin wax, which in turn, necessitates higher application temperatures and other relatively minor modifications of the paper waxing process.

In addition to bread, bakery products of a greasy nature are successfully packaged in such coated papers.

Low molecular weight polyethylene resins are also used without wax dilution particularly for more rigid packaging requirements such as encountered with frozen foods. The low temperature flexibility and moisture-vapor-transmission resistance are especially advantageous. This latter property aids in preventing "freezer burn" of refrigerator meats.

It will undoubtedly be of interest to the plastic industry to learn that techniques evolved in screw extrusion of plastics have been of value in utilizing plastic extruders to feed molten low molecular weight polyethylene resins to various types of coaters.

While the number of fields in which low molecular weight polyethylene resins are used at present is not numerous, they at least involve sufficient volume to aid in bringing prices on these materials down which, in turn, may open up new avenues in the strictly plastics field. Specialty fields are also stimulating work on various modifications of polyethylene such as pyrolyzed, oxidized, hydrogenated, and halogenated materials, as well as copolymers of ethylene with vinyl acetate, acrylates, and carbon monoxide.

All in all, it is believed the lower molecular weight materials will attract attention to plastics uses where the ultimate physical properties obtainable with higher molecular weight polyethylene resins is secondary to ease of handling and fabrication.

CONTROVERSIAL POINTS ON EXTRUSION

By HANS E. BUECKEN

National Rubber Machinery Co.

The feed screw, the very heart of the extruder, is perhaps most controversially discussed and, often with equally good results, applied. There are many varieties of feed screw designs. Two of the most universally applied types are the torpedo and the full-flighted as shown in figure 1.

The torpedo type screw[7] is so named because of the torpedo-like extension at the extrusion end, consisting of a section having an outside diameter as large or larger than the root diameter and a length several times the outside diameter of the screw. It may have a smooth surface or be provided with special flights and be either cylindrical or tapered or a combination of both. The torpedo, being an integral part of the screw, rolls or shears the relatively thin layer of plastic compound between the rotating surface of the torpedo and the stationary surface of the cylinder wall, thus not only an excellent and final mechanical mixing is achieved but also a more uniform and more efficiently conducted heat distribution, as well as a moderate and desirable but still controllable frictional heat. This condition is to a degree influenced by varying the temperature of either surface. The torpedo also serves as an accumulator, permitting a more uniform cross-sectional pressure distribution, thus eliminating or reducing pulsations at the die. Most operators feel that without this torpedo such compounds as cellulose acetate, butyrate, ethyl cellulose, polystyrene, saran and nylon (if one terms the "metering" section of a nylon screw a torpedo) cannot be extruded successfully i.e. at least not with close tolerances. The torpedo type screw is sometimes preferred for the extrusion of polyethylene because of the closer tolerances obtained with it, although lower production rates may then be realized.

A full flighted screw has no torpedo and the flights run to the end of the screw which may have a blunt or a pointed tip.

The flight section of the full-flighted, as well as of the torpedo type screw, can have either constant or variable pitch flights, a constant or variable root diameter or both of these variations; it can be single or double flighted, or single into double or vice versa. The double and the single into double flighted screw is frequently blamed as the cause for pulsations, appearing at large intervals, because it is claimed that the separate and independent channels formed by the double flight does not deliver the compound at equal speeds. If the compound is not being evenly divided at the start of the double flight, uniform delivery cannot be expected; but, this can only occur if the screw is not completely filled and the compound is not under uniform pressure at the start of the double flight, or if the screw is not uniformly machined.

A full flighted screw is generally recommended to be used for the extrusion of polyvinyl chloride and polyethylene, particularly in covering hose, cable and wire. A full flighted screw will also perform satisfactorily with some of the harder plastics when used with a large tubing die or any other arrangement which gives the effect of a torpedo.

Unfortunately in many instances, the design of a screw is governed by the type of equipment available, or by the cost restricting the type of equipment, to machine a screw. Naturally, a constant pitch and constant root diameter screw is very simple and can be machined at a compara-

tively low cost. Most extruders realize and appreciate that the performance i.e. the extrusion quality and capacity of an extruder, depends on the proper design of the flight section of a feed screw which is a direct function of the type and condition of the compound.

The volumetric compression, which is the ratio of the volume between two flights around the screw at the start and at the end of the flighted section, is very important.

Compression ratios as high as 8 or 10:1 are frequently applied. High compression ratio screws may become out of balance i.e. sectional or localized plasticization, which is a function of compression, conducted and frictional heat, may occur in the flights thus forming independent extruder stages causing pulsations or surging of the extruded profile.

For the extrusion of a powdered compound, the high compression ratio screw is of particular advantage because, considering the high differential of the heat conductivity of a compound in powdered form versus that of a compound in a densified form, which may be as high as 10 or 15:1, it would be naturally desirable to densify a powdered compound as highly and as quickly as possible by the flights but without plugging the flights and becoming "out of balance."

Inasmuch as frictional heat is a function of pressure, it becomes also a function of the compression and must not be neglected.

The screw temperature depends on the compound and the extrusion application and must be controlled. Many screws are drilled through the center, from end to end, for heating or cooling. Other screws are only partially center drilled, either up to or slightly past the feed opening of the extruder cylinder. This is to cool the screw through the feed section and to let the rest of the screw, in particular the torpedo, be heated by the compound and the cylinder. The latter method is especially important when extruding rigid compounds with a torpedo type screw because cooling of the torpedo would form a hard shell around it, while cooling of the feed section is desirable to maintain maximum production. Another reason for keeping the feed section of a screw cool is to filter air or other volatile gases that may form under pressure and heat, through the cold compound and vent through the feed opening of the cylinder. Actually the better method of controlling the screw temperature is by the use of the dual controlled type which has an independent circulation for the flight section and the torpedo and is described in further detail in the Dow Chemical Company's Patent No. 2,449,355.

Many extruders prefer to work with a "neutral" screw i.e. with a screw which is neither heated nor cooled. The "neutral" screw is used in the extrusion of nylon.

The efficiency of a feed screw for thermoplastic compounds is unusually low. Although some installations operate at a screw efficiency of 40% and, maybe 60%, a good average efficiency is 10 to 15%.

The volumetric efficiency and the quality of the extruded product are greatly influenced by the "mechanical" efficiency of the screw, which is a function of the clearance between the outside diameter of the screw and the cylinder bore, the size and shape of the fillet in front and rear of the flight and the condition, i.e. the sharpness of the flight edges maintained at the outside diameter of the screw. This is of special importance when extruding compounds that become very fluid when heated at plasticizing temperature, such as Saran and nylon.

Close tolerances, high volumetric and mechanical efficiency are a direct function of the quality of the screw, the material it is made of and the procedures employed to build the screw, in addition to the proper design.

Most extruderers are of the opinion that the general specifications of a standard feed screw, expected to give good service for a reasonable length of time, should call for a steel alloy forging, heat treated to a machinable hardness and chrome plated; the flight lands should be surface hardened to a hardness of approximately 50/55 Rockwell "C", or covered with Stellite, Stoody No. 6, or similar materials. Steel alloy screws, for the extrusion of nylon, have the flight lands covered with bronze such as AMPCO-Trode 10 and 10 "AC" Electrodes[1] which are recommended for over-laying bearing and wear-corrosion resistant surfaces for those applications not requiring higher hardness values.

However, feed screws for the extrusion of Saran are an exception to this as they are made preferably of Z-Nickel which can only be heat treated to a Brinnel hardness of 325/350; and, the flight lands can only be hard surfaced to a Brinnel hardness of approximately 425 by cold working. Z-Nickel is an alloy containing approximately 98% nickel. As annealed, it has a tensile strength of 90/120,000 p.s.i. and a Brinnel hardness of 150/225. When heat treated, it has a tensile strength of 160/180,000 p.s.i. and a Brinnel hardness of 300/350.

The application of Stellite or similar materials to Saran screws is for many reasons not recommendable. Stellite is a cast non-ferrous metal consisting of approximately 12 to 17% tungsten; 30 to 35% chromium; 2.25 to 2.27% carbon and the balance principally cobalt; it has a Brinnel hardness of approximately 600.

The thin layers of these extremely hard metals, having practically no elasticity, must crack when the comparatively elastic Z-Nickel twists even under its normal operating load, creating crevices for the compound to hang up and to decompose. Although they are only minute particles, they can cause serious damage to the product. In addition, the fusion of the two metals leads to an inevitable but sufficient porosity to permit entering of corrosive gases that become free at extrusion temperatures causing gradual corrosion sufficiently serious to weaken the fusion to such an extent that pieces of the hard metal may break off the Z-Nickel screw during operations.

The possibility that these conditions will occur on a steel alloy or stainless steel screw is more remote since neither one is likely to twist sufficiently under normal operating load to crack the hard metal. The line of fusion is covered on a steel alloy screw by the chrome plating which is not the case of a stainless steel screw; although, a stainless steel screw may not be subjected to compounds of extremely high corrosive nature. Some stainless steels have poor welding qualities and hard surfacing material cannot be applied.

Another type of surface hardening is the nitriding process. Articles to be nitrided are exposed for 48 hours to ammonia gas, which at 950 deg. F. decomposes into nitrogen and hydrogen. The nitrogen combines with iron and alloying elements to form nitrides which are in a fine state of dispersion in the surface to a depth of .010" to .050", and impart extreme hardness to the surface of the steel of 700 to 1100 Brinnel. All heat treating must be done before nitriding.

If maximum surface hardness is expected, special alloy steel containing such elements as aluminum, molybdenum, manganese, chromium, vanadium, titanium and tungsten to form nitrides of extreme hardness on the surface are required. These alloy steels are commercially available under the trade name of Nitralloy.

Stainless Steel Types 329, 416 and 420 are recommendable for certain screw applications and are suitable for nitriding. **Stainless steel type 329**[0] with 27.5% chromium is more corrosion resistant than the 20% chromium iron. **Stainless steel type 416**[2] has non-galling and non-seizing properties: it is corrosion resistant to water and some chemicals, and is difficult to weld or braze. **Stainless steel type 420**[3] is corrosion-resistant to water and some chemicals and is never used annealed.

Inasmuch as the alloy should be heat treated before being nitrided, the proper tensile strength for the core can be obtained in addition to an extreme surface hardness. The nitrided case is relatively thin and

the surface hardness reduces gradually to that of the core. If properly nitrided cracking is minimized; although flaking of nitrided surfaces, possibly due to galling, has been reported. Four of the various types of feed screws heretofore discussed are shown.

LINERS

Today the cylinder of all extruders for thermoplastic compounds regardless of size are provided with special replaceable, wear and corrosion resistant liners. However, although the liner can be readily removed, it must be properly secured against rotational and longitudinal motions. At the same time, it must be permitted to expand or contract independently to prevent harmful stresses without losing its direct contact with the cylinder in order to maintain its efficient heat transmission. This latter condition is particularly prevalent during fast preheating or quick cooling periods. The bore of almost all liners used for the extrusion of thermoplastic compounds is smooth and extremely well polished. Although there are installations applying grooved liners, these grooves may vary in size and cross-sectional shape. They may be longitudinal or helical and may run the full length of the liner at full depth or be of tapering depth and of partial liner length. Grooves are only of value where they further the transfer of **all** the parts of the compound through the extruder and not cause **some** parts to remain in the extruder to be exposed too long to the heat and decompose.

In general, Xaloy 306 liners work quite satisfactorily in direct electrically and oil heated extruders. A soft or heat treated steel liner with a chrome plated bore is regarded today as inferior and should not be used in a production machine. Even the best chrome plating is not permanent under the severe service it is exposed to.

Stainless steel, corrosion resistant only to a certain extent, is generally not recommended as a liner material for production machines. Although it is comparatively soft, it has good wear resistant qualities. Stainless steel liners may be nitrided and a harder and substantially improved wear resistant surface may be obtained. However, nitriding does not improve the corrosion resistance to any extent. Therefore, as long as chrome plating has to be applied, it is better to use Nitralloy, a special steel alloy recommended for nitriding which may be heat treated to obtain a tube of a high tensile strength with an extremely hard and wear resistant surface. Such liners, even without chrome plating, would be applicable for the extrusion of polyethylene and nylon, both non-corrosive compounds. However, it is claimed that the surfaces of nitrided liners have become gradually annealed by the frequent exposure to higher extrusion temperatures such as are used with nylon.

Many liners used for the extrusion of most thermoplastic compounds are of seamless steel tubing provided with a centrifugal cast-in Xaloy 306 lining approximately .060" thick, having a Rockwell hardness of 48/52 "C", and are honed to an extremely smooth finish. Xaloy 306 has unusual corrosion resistant qualities and has excellent wear resistant properties. The chemical composition of Xaloy 306 is 38% nickel; 38% cobalt; 8% chrome; 6% molybdenum; 4% silicon and 3% boron.

For the extrusion of Saran mainly from the standpoint of catalytic reaction, Z-Nickel is the recommended liner material. Although having a Brinnel hardness of 325/350, its resistance to wear is low. Furthermore, although the screw may be slightly harder, galling of liner and screw is eventually inevitable if their respective surfaces should come in direct contact under pressure, as both parts are of Z-Nickel. Not only is the initial cost of a Z-Nickel liner high but its frequent replacement does not make it appear to be an economical liner as far as the liner cost is concerned.

The initial cost of Hastelloy "B" liners is still higher than Z-Nickel but the corrosion resistance and catalytic reaction of Hastelloy "B" to Saran are well within acceptable limits; the Brinnel hardness is approximately 210/235 annealed and 400/475 heat treated. Therefore because in the heat treated condition the wear resistance and the resistance to galling has been considerably increased, it is quite an improvement over the Z-Nickel.

Hastelloy "B"[4] is a nickel, molybdenum, iron alloy containing small portions of carbides and is used for wear resistance and resistance to galling and seizing. Particularly well suited for equipment handling "boiling hydrochloric acid" and "wet hydrochloric acid gas," it has high corrosion resistance in hydrochloric acid solutions of all concentrations and at all temperatures up to the boiling point.

For the extrusion of Saran or nylon and other compounds that become very fluid when heated at plasticizing temperatures, it is imperative that the clearance between the outside diameter of the screw and the liner bore be kept at a minimum.

The Xaloy 306 liner having the least wear, therefore, should be the most suitable liner. However, the hard lining being practically non-elastic could crack or craze in multiple longitudinal hairfine cracks if stressed beyond its elastic limit when accidental or other unusual forces, including thermal forces due to rapid heating and cooling, cause the base liner and cylinder to expand beyond their elastic limits. This condition, of course, is detrimental because any part of the compound that may lodge in the cracks can decompose and become loose. Therefore, a cracked liner must be replaced at once.

CYLINDERS

Thermoplastic extruder cylinders are heated by circulating steam or oil or by electricity. Steam heating is the oldest and most reliable, providing it is available and temperatures are within a practical steam pressure range. Oil heating is not so old but is as reliable and recommended up to temperatures of 600 deg. F. It is often erroneously regarded as inefficient and it is for many obvious reasons definitely out of question for extremely high temperatures. Electrical heating is as old as oil heating; it has become only recently very popular because of newer compounds or compounds now available in more abundance requiring higher extrusion temperatures and because more experience has been gained in the extrusion of thermoplastic compounds.

In order to obtain a close tolerance extrusion, it is necessary that the operating heat and temperatures of the extruder be in complete balance. Therefore if during extrusion more frictional heat is created than can be absorbed by the compound without raising its plasticizing temperature above normal, a direct electrically heated extruder **cannot** be applied without obtaining a pulsating extrusion unless a means to remove the excess heat is provided.

Heat always flows from the high temperature region to the low temperature region. Therefore if the compound in the cylinder becomes overheated, the cylinder wall, in order to absorb the excess heat of the compound, must be cooler.

The heater control actuated by the reaction of the pyrometer of the temperature control shuts off the current supply to the heater but NOT the HEAT of the heater, and because of the inertia and the higher temperature of the heater, the portion of heat which is not radiated into the room is absorbed by the cooler cylinder wall thus preventing the excess heat of the compound from dissipating, unless the cylinder wall is sufficiently cooled. Therefore, in the past, zoned, jacketed or cored cylinder walls have been provided for the circulation of a cooling medium such as low pressure steam, water, or compressed air, and even cooled oil has been suggested. But such arrangements can hardly be classified as improvements if, besides the electrical heating installation, steam, water or compressed air connections with valves and possible controls or even an oil cooling unit must be provided which are costly to install and uneconomical to operate.

The length of an extruder cylinder depends on the size of the extruder and the extrusion capacity expected to be obtained from it. The BTU required to heat a pound of thermoplastic compound at a certain temperature differential in one hour depends on the specific heat[5] of the compound and does not vary with the size, type or make of an extruder. The heat required to plasticize the compound can be introduced by conduction and through friction. If a unit area of the cylinder wall is to transmit a required amount of BTU into a pound of compound per hour by conduction, then outside of the temperature differential, the rate of conduction depends entirely on the thermal conductivity[6] of the compound and does not vary with the size, type or make of an extruder.

The length of a cylinder with a given diameter bore and of a given extrusion capacity is then a function of the unit area required.

Frictional heat is converted horsepower. It is limited to the amount of BTU required to plasticize a given quantity of compound. It creates additional thrust and torque on the feed screw which must be considered when selecting the size of thrust bearing, gear transmission and the drive motor.

Frictional heat is produced by an indirect source affected by the efficiency factors of the gear transmission and drive motor; expensive equipment with rotating parts requires constant service and maintenance, and gives difficult heat to control.

It is further obvious that the extruder is not a "perpetual mobile" and that the laws of physics apply. Therefore if a certain amount of work is to be done to a quantity of material in a specified time, whatever the amount, quantity and time, it will be the same for any type and any make of extruder. But, it must be remembered that even so work, quantity and time does not change during the same operation; the work is a product of conducted heat and of horsepower partially converted into frictional heat and partially into power to move the material. This means that in order to do the **same** work in the **same** time, the size of the thrust bearing, gear transmission and drive motor varies with the length, as does the size of the cylinder. In other words, an extruder with an extremely short cylinder would require a much larger thrust bearing, gear transmission and drive motor than an extruder with a rather long cylinder to do the same amount of work.

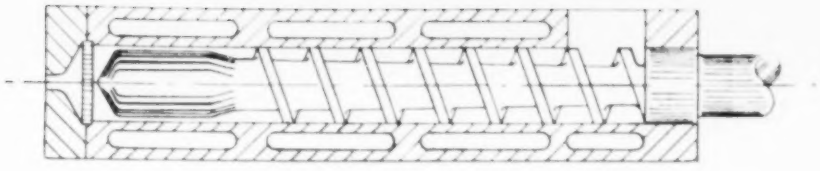
The first plastics extruders were provided with rectangular, sharply tapered side feed openings one side of which would blend tangentially into the cylinder bore under the screw. The shape of this type of opening, with the exception of the undercut which had been omitted, was an adoption from the Rubber Tuber and made the application of a funnel, agitator or stuffer, essential for granule and powdered feed, too difficult.

Soon it was recognized that a rectangular feed opening located in the center of the cylinder above the screw with two tapered sides blending tangentially into the cylinder bore would function as well or better. If the neck of the opening is kept short, tapering of the walls is not required. This shape of feed opening still requires much hand finishing to be properly prepared for chrome plating and to fit the liner opening, and is still not perfect for the application of auxiliary feeding equipment. These difficulties were finally eliminated with the adoption of the round type feed opening which is a straight bore machined to the same diameter as the screw.

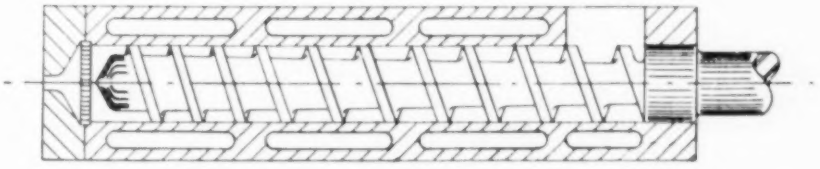
For the feeding of strips and "chunky" materials with large bulk factors, the rectangular or side feed opening is still preferred. Instead of undercutting the cylinder, the screw is undercut for strip feeding.

The feed section must always be cored or jacketed for the circulation of a cooling or heating medium. For most compounds, a cold feed section is required but occasionally heating is preferred. In any case, the compound must be prevented from becoming soft and agglomerating in the feed opening.

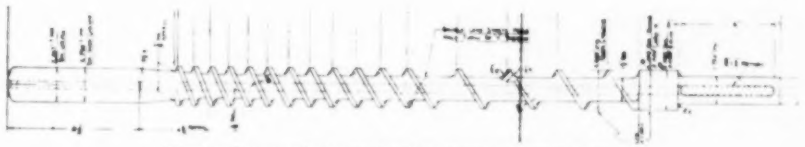
The number of heating zones, their length and their respective temperatures are also points of strong controversial opinion. The rate with which a compound can absorb heat is



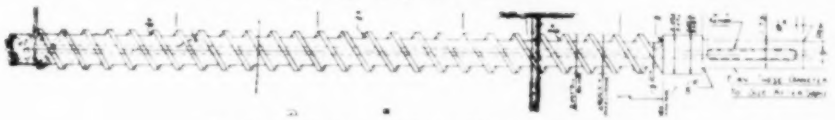
TORPEDO TYPE SCREW



FULL FLIGHTED SCREW

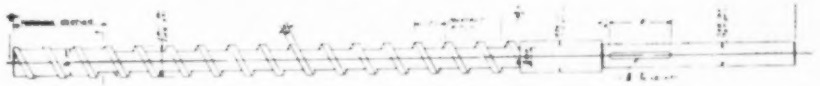


Typical torpedo type feed screw - single into double - flighted section.



Typical full double flighted feed screw.

Typical Saran torpedo type single flighted feed screw.



Typical single flighted Nylon feed screw with "metering" section.

a direct function of the thermal conductivity[6] and the temperature difference between the compound and the adjacent cylinder wall. In other words, assuming that the thermal conductivity remains constant, the greater this temperature differential the more conducted heat will be absorbed by the compound.

While the temperature of the compound gradually increases as it moves through the cylinder subjected to the same cylinder temperature, the temperature differential and subsequently the rate of the heat absorption decreases. It would then seem logical that in order to maintain a uniform and maximum rate of absorption, a constant temperature differential should be maintained and the cylinder wall temperature should, therefore, gradually be increased in the same proportion as the temperature of the compound increases. This, of course, is impractical as the cylinder wall temperature would soon become so high that the compound in direct contact with it would scorch and, unless the compound is kept moving, the conducted heat would be absorbed by the compound until it reached the same temperature as the cylinder wall and decomposed.

The amount of heat required to heat a given quantity of a certain compound to a specified temperature in an extruder is a direct function of its specific heat and the change in temperature desired. It is reduced gradually and theoretically to zero in the same proportion as the temperature of the compound is increased as it is moving through the cylinder until it reaches its final plasticizing temperature. Therefore, because the temperature differential can be reduced, the cylinder temperature can be reduced proportionally toward the extrusion end of the cylinder or, at least, remain the same for all zones. However for the same reason as it may be desirous to keep a cool feed section on the feed screw, it may also be desired to keep the zone adjacent to the feed section considerably cooler. These conditions can very effectively be achieved with two or three heating zones in addition to the feed section.

The heat in an extruder cylinder will flow radially as well as longitudinally. Therefore, as the often large exposed surfaces at the die end and the cooled feed section draw more heat because of these heat losses, the center-section of a very long cylinder, not having such extreme heat losses, has the tendency to remain hotter and, since the temperature control instrument does not call for heat as for the other zones, appears overheated. As long as this instrument indicates the desired temperature, it is actually controlling the heat input.

Heat will also flow from a heating zone of higher temperature to an adjacent heating zone to a lower temperature. Because of this equalizing impulse, it cannot be expected that a very narrow heating zone with a limited heater capacity can produce an effective temperature variation on the cylinder wall. Although by observation of the control instruments a narrow heat zone may appear effective as the instrument at the high temperature zone may call constantly for heat, while "trying" to indicate a temperature that can only be reached after sufficient heat has been supplied by the high temperature zone, the narrow heat zone is forced to supply the adjacent low temperature zone with heat, keeping the latter control instrument "off."

Separation of the narrow zones either in space or by insulation is possible but not a great advantage because the heavy cylinder wall is of little interference to the flow of heat across the comparatively short distance of the narrow zones.

In conclusion, the author wishes to stress again the fact that most of the points discussed are "controversial."

(1) *Ampco-Trode 10 and 10 "AC" Electrodes. The approximate chemical composition is: 90% copper, 8-3/4% aluminum and 1-1/4% iron. When the base metal is steel, the mechanical properties are: 91,000 p.s.i. tensile strength; 43,000 p.s.i. yield strength; 120 Brinnel hardness; 250,000 p.s.i. elastic limit and compression; 120,000 p.s.i. ultimate compression. Brinnel hardness of other Ampco-Trode Electrodes of approximately the same mechanical properties are: Ampco Trode 160—Brinnel hardness 160; Ampco Trode 250—Brinnel hardness 250; Ampco Trode 300—Brinnel hardness 300.*

(2) *Stainless Steel Type 416. Physical properties are: Annealed at 70 deg. F., yield 65,000 p.s.i.; tensile strength 86,000 p.s.i.; at 900 deg. F., yield 35,000 p.s.i.; tensile strength 48,000 p.s.i. Hardened: Heated to 1825/50 deg. F.; soak and quench in oil; drawn to 300/800 deg. F.; elastic limit 45/80,000 p.s.i.; yield 137/127,000 p.s.i.; tensile strength 166/164,000 p.s.i.; Brinnel hardness 351.*

(3) *Stainless Steel Type 420. Physical properties are: Hardening, heated to 1800/1850 deg. F.; soak and quench in oil; draw to 300/400 deg. F.; cool in air; hardness approximately 52/53 Rockwell "C"; Brinnel hardness 512; elastic limit 225,000 p.s.i.; tensile strength 269,000 p.s.i.; must be* GROUND ALL OVER *to remove scale.*

(4) *Hastelloy "B". Physical properties are: Hardening anneal, Temperature 1375/1400 deg. F.; time one week; cooling in air; Rockwell "C" 40/50; Brinnel hardness 400/475; Hastelloy "B" can be machined only at comparative low cutting speeds.*

(5) *Specific Heat is the amount of heat in BTU required to raise the temperature of one pound of a substance to one deg. F.*

(6) *Thermal Conductivity is the quantity of heat that will flow across unit area in unit time if the temperature gradient across this area is in unity. (BTU/(hr) (sq.ft) (deg.F/ft).*

(7) *Patented by National Rubber Machinery Company.*

(8) *1 horsepower equals 2546 BTU per hour; 1 BTU equals .000391 horsepower per hour.*

(9) *This design has been developed by National Rubber Machinery Company and patents have been applied for.*

(10) *Stainless Steel Type 329. Tensile properties. Annealed by either single or double treatment: elastic limit 70,000 p.s.i.; yield point 80,000 p.s.i.; tensile strength 105,000 p.s.i.; Brinnel hardness 230. It can be readily welded and brazed. Hardening renders the steel quite brittle, having about the same toughness as a good grade of cast iron, therefore not recommended for screws.*

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FIELD MOLDING PROBLEMS

By C. J. SNYDER
Koppers Co., Inc.

Field molding problems can be expected to arise with the introduction of new plastic products, new dies and new materials. Rapid advances in plastics materials, methods and machines in the last five years have made molding operations considerably easier. However, the consuming public and the spirit of competition have further instilled inventors and manufacturers with the desire to produce larger and more complicated articles. Such production has consequently created new and different molding problems which, in most cases, are far more serious and costly than any which have gone before them. They are more serious and costly because of the higher initial investment in dies and machines and the actual material and labor cost when these larger and more complicated parts must be scrapped. Treatment of this subject will be held to the field of injection molding. Although other phases of plastics molding and forming also present field problems, injection molding of thermoplastics has expanded so rapidly in the past few years that problems concerning this phase of the plastics business will be of more general interest.

A molding problem exists whenever losses occur. These may be losses in finished parts because of scrap or lost production time or they may be losses created by improper engineering and quotation. No matter what the basis is, a manufacturer must operate at a profit in order to stay in business. Although the problem may not stem directly from molding techniques, it must be eliminated.

Common molding troubles which arise are: (1) short or incomplete shots, (2) parts rejected because of surface and interior marks, (3) cracked or broken parts caused by sticking, (4) imperfections and cracks showing up after storage or use periods, and (5) lost production because of improper or erratic cycle.

These troubles are generally caused by improper molding conditions, poorly designed dies, the use of materials other than those for which the dies were designed, the use of scrap or rerun material, using the molding machine beyond its capacity, or the use of molding machines in poor mechanical condition. These causes either singly or in combination are sometimes sufficient to create unnecessary losses in parts, production time, material, and ultimately, dollars and cents.

It is a rare occurrence when two different jobs can be run under exactly the same molding conditions. These conditions even on the same die often change drastically from one run of the same job to another run, especially if an appreciable time has elapsed between the two production runs. In fact, a change of atmospheric conditions will often cause a series of moldings to go awry. For example, water commonly used for cooling dies is much colder when taken directly from supply lines in spring, fall, and winter than it is in summer. Such differences in water temperature bring about corresponding differences in die temperature which must be compensated for by changing some of the "standard" molding conditions. It may be as simple as closing a water valve or it may mean that a complete change in molding temperatures and cycles must be effected.

Cylinder temperatures are probably the most important factor. Improper cylinder temperatures result in either insufficient or excessive material softening. This in turn creates erratic molding conditions. Temperature settings must be made only after due consideration has been given to material softening point, heat distortion temperature, design and capacity of die, and material handling capacity of the machine cylinder. Temperature gradient through the cylinder is also important to the attainment of proper molding. In most cases, the temperature of the front part of the cylinder should be higher than that of the rear. In some instances it has been found that an equal temperature, front and rear, is best. However, it is generally poor practice to have the temperature of the rear higher than that of the front. Practices of this nature are prevalent in many molding shops and have been found to give trouble.

Injection and clamping pressures are important items to consider. Insufficient injection pressure causes short shots and excessive injection pressure produces flash, die sticking, overweight parts, and cracked pieces. Insufficient clamping pressure gives flashed pieces and cocked dies, while excessive clamping pressure puts undue strain on the machine and die parts.

Cycle is important in determining the number and quality of parts produced per unit time. Plunger time determines the fill of the piece and material packing effectiveness. Cooling time is a prime factor in determining quality, appearance, and dimensional stability of the finished piece.

Die temperature is one of the important factors of the degree of finish, the quality, the fill, the dimensional stability and the control of stresses and strains. A consideration of the job and the factors involved determines whether warm, cold, or half and half dies must be maintained.

The importance of proper feed as one of the molding conditions is self-explanatory. A slight and constant cushion on the injection stroke of each shot will aid in maintaining smooth operation.

Poorly designed dies make excessive scrap. Unbalanced dies are hard to control due to feed pressure differences, clamping pressure, and die heat control. Undersize sprues and runners do not supply sufficient feed rapidly enough to fill out the piece. Gates can be too small for satisfactory molding, but in most cases they are made too large. It is always good practice to start out with the smallest gate possible and enlarge if necessary. Gates can be opened, but it is extremely difficult to close them off once they have been made too large. Good molding practice today is based on the principle of restricted gating.

When the practice of restricted gating is used, the tool designer and the molder must not take this as their cue to reduce the quantity of feed to the gate. The gate may be made small but there must be a sufficient quantity of material fed in order to make a complete piece. It is not uncommon to find dies in which the sprue and runners have been made so small as to provide an insufficient rate of feed to make the piece before the material sets after leaving the heating cylinder. The matter of sprue and runner size coupled with the size of nozzle used on the machine is very important and as in the case of gating, it is always advisable to make them as small as possible. However, it should also be recognized that there is nothing to prevent making them larger whenever incomplete parts are obtained due to insufficient feed.

Another mold design factor is that of providing sufficient draft in the die to enable the operator to remove the molded part from the die easily. Underdrafted dies continually give sticking problems and high production losses. It is always good economy to allow as much draft on a die as possible without harming the utility or design of the finished part. It is better to have too much draft than too little draft.

Servicemen of material suppliers are constantly encountering the prob-

lem of running unbalanced dies. This problem is prevalent inasmuch as many molders are attempting to make a complete product in one shot in the same die; for example, a box, lid, and insert. This poses a very definite question as to the proper method of making such dies and should present a challenge to the tool designer as to the layout of such a mold. The main factors to be considered are those of mold area as correlated with the available clamping area of the machine, the type of die heating and cooling to be used and, most important of all, the location of heating and cooling channels, inlets, and outlets in the die. One factor not generally taken into consideration in multiple cavity dies is that thin sections do not require as much die heating or cooling as do heavier and thicker sections.

The finish of the die is of major importance, not only because it is reflected in the finish of the molded article, but because good die finish promotes improved moldability. Wherever possible, excluding instances where a satin or dull finish is desired, the die should be polished as highly as possible, preferably to a mirror finish. This method is preferable to chrome plating because chrome plating may introduce additional problems in the form of uneven plating, giving irregular thicknesses in the molded part. Chipping off of the chrome plating while in use may also occur. It has generally been found unsatisfactory to rechrome chipped plating without going to considerable expense and trouble. It is becoming accepted throughout the trade that a high polish on steel is more desirable than mirror surfaces obtained by chrome plating. Plastic parts today, and particularly plastic molding dies, must be engineered and not merely designed.

Die design should be correlated with the molding characteristics of the type of plastic molding material to be used. The thermoplastic molding powders have molding characteristics which make each different from the other. Therefore, dies must be designed to take advantage of the best characteristics of a molding powder suitable for the application.

Similarly, due consideration has to be given to the conditions to which the finished part will be subjected. Therefore, it behooves molders and manufacturers to consider the end use application before the mold is designed. By doing so, he will not only reduce use problems, but also will measurably decrease molding problems. On numerous occasions it has been found that dies were designed to use one type of molding powder only to have end use considerations demand the use of another material.

The feeding back of scrap, reground or rerun material always introduces molding problems. For quality products, virgin material should always be used. However, there are occasions where quality can be somewhat sacrificed in view of what seems to be economy. In these cases, it has been feasible to feed back reground material. There is, however, always the possibility that by doing so the molder will run into problems of erratic molding conditions, contamination, and material breakdown. This breakdown is caused by chemical changes brought about by the application of heat and pressure the first time through. Because of their organic chemical nature, both unplasticized and plasticized plastic molding powders change to a degree. In addition, plasticized materials change more due to the loss of plasticizer during the molding operation.

Another source of trouble can be traced directly to overloading molding machines. This is done in two ways: (1) by attempting to mold parts whose total weight, including sprue and runners, is greater than the rated capacity of the machine and (2) by building dies which have too large an area for the press, thereby giving poor clamping. The first of these is more serious inasmuch as more attention is paid to the latter when a job is lined up.

Injection molding machine cylinders are rated on the basis of cellulose acetate. Materials with a specific gravity different from that of cellulose acetate will accordingly change the machine cylinder weight capacity. That is, molding powders having a specific gravity lower than that of cellulose acetate will actually lower the machine capacity in respect to the weight of material that can be injected. Materials having a specific gravity higher than that of cellulose acetate will accordingly raise the capacity of the machine with respect to the weight that can be softened. For example, an eight ounce machine is rated on cellulose acetate with an approximate specific gravity of 1.35. The same machine using polystyrene with a specific gravity of 1.05 would, if rated according to polystyrene, have a capacity of 6.35 ounces. Similarly, using cellulose nitrate at a specific gravity of 1.42, the machine would have a rated capacity of 8.4 ounces.

Many molders are unaware of this fact and misconstrue the rated capacity of the machine by assuming that an eight ounce injection molding machine has an eight ounce capacity regardless of what material is used. Accordingly, they design dies for pieces weighing up to eight ounces, and then use a material such as polystyrene, with the result that they encounter all manner of problems in the form of short shots, shots with surface and internal marks, etc. Many molders knowingly do the same thing and invariably end up in trouble. Here again, a consideration of the physical characteristics of the particular molding powder which is selected is of prime importance. Bulk factor of materials should be especially noted before any new job is undertaken.

Even though all factors may have been considered in regard to materials, proper die design, etc., a significant source of molding problems comes from equipment in poor or unusable mechanical condition. The roots of this trouble are: (1) overworked and worn-out pumping systems, (2) burned out heater bands and thermocouples, (3) controllers out of adjustment, and (4) worn machine parts. The solutions to problems created by the aforementioned conditions are obvious. Faulty equipment will not produce perfect parts no matter how good any material might be or how skillful a die designer or machine operator may be.

Although it is not strictly a molding problem, it is well to consider the forces which may act upon a piece after it has been molded. The resultant damage can in many cases be traced back to improper molding conditions. Some points to consider are physical stresses and strains set up in the molding operation, exposure to chemical attack and exposure to outdoor weathering. Stress relief of parts is often necessary to prevent cracking and crazing of molded articles in storage or use. This is accomplished by annealing and similar operations. Each plastic material is unaffected by certain specific chemicals and attacked by others. It is easy to avoid any pitfalls in this matter as information concerning chemical resistance and attack is readily available from material suppliers. Outdoor weathering affects some plastic types more than others. Whenever outdoor applications arise, the properties of any suitable material must be thoroughly examined in order to be certain that it is resistant to weathering. Actual tests of molded parts are usually necessary in order to arrive at a final answer.

Numerous illustrations of each of the points mentioned previously can be cited from actual field problems which have been encountered. Case histories indicate, however, that most field molding problems could be prevented by closer cooperation between the designer, tool maker, molder and material supplier.

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MAKING PLASTICS MOLDS

By J. L. MORRISON
Detroit Mold Engineering Co.

Machinery

The equipment that comprises a mold-making shop is basically the same as it was fifteen years ago. The vertical mill is still the heart of every mold shop. It is the same machine that sank drop forging dies in the World War I except that ball or roller bearings now replace bushings in the spindle, and head travel and table travel are hydraulically or electrically actuated, and accuracy of work is now less dependent on the operator than on the machine.

This is, of course, over-simplification, but the fact remains that the main change in tool room machinery has been in quality rather than kind or type. We are still using vertical mills, horizontal mills, boring mills, lathes, shapers, grinders, planers, drills, pantographs and hydraulic presses.

The growth of the plastic molding industry and the metal die casting industry has resulted in a tremendous increase in mold making shops. For many reasons these shops have remained relatively small—the fifty-man shop is still larger than average. Since big dies were not in great demand fifteen years ago, the small shop did not find it economically feasible to invest in a great deal of heavy equipment that could not be kept busy. For example, large duplicators or Kellers were seldom found in a plastic die shop and jobs requiring this equipment had to be farmed out. Many times those people who did have heavy machines were not familiar with the finish required on molds. The resulting profiling added hours to the task of benching because too much stock was left. Today the increasing demand for large dies makes it imperative for the mold-maker who wishes to be competitive on dies of all sizes, to have large milling equipment.

Other types of machining such as grinding, boring, turning and planing can more easily be sub-let, but profiling is usually safer in the die shop.

World War II forced the development of machines of great accuracy, many of which found their way into plastic tool rooms after the war. The machinery dumps in Chicago, Detroit, Buffalo and the east coast were a happy hunting ground for many mold makers, and the starting point for many mold shops. In size, mold making equipment is roughly paralleling molding machines.

The Steel

Since the end of the war a great deal of time and effort has gone into research and development of steels for the plastic industry. The majority of the work has been directed toward improving hobbing steels—and with considerable success. Prewar hobbing steels were largely of two types—the plain carbon or hobbing iron, which is still very popular—and the chrome-nickel type similar to AISI-3110. The plain carbon was and is the most easily hobbed, but lacked the physical properties of the alloy steels. In steel making as in the rest of life—you can't have your cake and eat it too. It just isn't possible to make a strong alloy steel as easy to hob as the plain carbon variety. However, decided improvements have been made.

Two steels with a Brinnel hardness between 105 and 110 are very popular. One is Crucible Steel Company's Formold, analysis: carbon .07, chromium 1.35, nickel .55 and moly .20, and the other is Carpenter's Samson Extra, analysis: carbon .10, manganese .30, silicon .20 and chromium 2.30. Both steels have superior hobbing characteristics to AISI-3110 which was for years the standard alloy hobbing steel, besides developing considerable more core strength on heat treatment.

Two other steels made by these same companies have a Brinell hardness about 125. One is Crucible's Airmold—analysis: carbon .07, chromium 5.00 and moly .50. The other is Carpenter's Super Samson—analysis: carbon .10, chromium 5.00, moly .90 and vanadium .25. The hobbing characteristics are better than AISI 3110 and the physical properties are exceptional. Core hardness runs Rockwell C-35—38 which is higher than on many tool steels. This type steel is being widely used in die casting dies.

All four of these steels are hardened by carburizing and in each the rate of carbon pickup has been greatly increased. Carburizing too heavily may lead to selective carburization and the familiar orange peel finish.

There is another steel which is so new that I hesitate to report it as an accomplished fact, but whose properties are so remarkable as to warrant close watching. There is a phenomenon known to metallurgists as "precipitation hardening." The age hardening of very low carbon steel used in sheet metal stamping is an example of precipitation hardening working against us. Carbon free iron combined with certain elements has been found to increase in hardness as much as thirty points on the Rockwell "C" scale when heated to only 950° F. However this has been mainly a laboratory problem and one that certainly didn't affect mold makers.

Now, both Crucible Steel Co. and Latrobe Electric Steel Co. have announced precipitation hardening mold steels for die casting dies. The analyses are undisclosed. The steels come pre-heat treated to about 212 Brinell and are hardened by a prolonged soak at 950° F. during which the hardness rises to about 385 Brinell or 40 Rockwell "C". This takes place with practically no distortion. In either large plastic molds or die casting dies, this freedom from size change is of great importance. It is also claimed that the steel takes a superior finish. It has been hobbed successfully on shallow cavities. The hardening temperature is the same as that used for nitriding, and it seems the steel also takes a nitrided case very well. It is our fervent hope that the advance notices have not been exaggerated.

The amazing thing about steel making to me after a trip through a steel mill, is that it can be made as clean and as uniform as it is. No industry demands a cleaner product than the plastic industry. Everything considered, the steel makers deserve high praise for giving us steel as good as it is. But, regardless of how much care they take, impurities are bound to creep in.

Steel is poured from a furnace into an ingot and allowed to cool. Impurities such as sulfides and oxides concentrate in the center and top of the ingot. After cooling, the ingot is cropped—that is—cut off at the top where impurities are most concentrated. The more the ingot is cropped, the more expensive the steel. Next the ingot is prepared for rolling or forging by torch cutting away bad surface areas. During forging or rolling, it is possible for surface oxides or scale to be worked into the steel. If the steel cools too much during work, an internal burst may appear.

It is common practice to check tool steel by acid etching a piece cut off the bar in question. This will disclose many flaws, but it is no guarantee that there isn't a gross defect within six inches of the cut section. XRay is of only limited value in checking steel, and if the section in question is over four inches thick, XRay is not practical. Magnafluxing has been used to detect cracks and surface flaws too small to be seen with the eye. However, it tells us nothing as to what the inside of a piece of steel may be like.

There cannot be a mold maker who has failed to have the sad experience

of finding a piece of steel dirty or defective after machining or benching was complete. The partially finished cavity may represent several thousand dollars in labor to the mold maker, but as a piece of defective steel it is worth only its original purchase price from the steel maker. As we noted earlier, plastic molds are drastically increasing in size, and therefore it becomes increasingly important that steel for cavities be as perfect as possible.

Seeing Through Steel

The proprietor of one of the largest and best forging shops in the middle west recently made the statement that he estimated that ten per cent of the forgings supplied by them as die blocks were not satisfactory for plastic molds for one reason or another. He went on to say that the flaws often were in areas not cut into by the cavity and so did not come to light; some were caught at the forge; and some—well, it was too bad—but you can't see inside a piece of steel.

Our forge man was only partly correct. There is in daily use in the shop of the Detroit Mold Engineering Co. a Sperry Reflectoscope which is doing a better than average job of looking inside die blocks. A brief description of this miraculous instrument is here in order.

The Reflectoscope is manufactured by the Sperry Products Corporation of Hoboken, N. J. who were responsible for so many of the recent applications of science to war-making. The unit is a portable generator of supersonic waves which are the same as sound waves but extremely short.

The waves, in frequencies of 1, 2¼ and 5 megacycles, are transmitted into the material to be tested, through a quartz crystal, ground to one of the three wave lengths. Contact between tested material and the crystal is aided by applying oil or glycerin and aerosol to the material.

The waves are transmitted or projected through the material and are reflected from the bottom of the block, back to the crystal, which acts also as a receiver. Both initial pulse and back reflection are shown on a cathode ray oscilloscope. In effect we are measuring the length of time it takes the pulse to go through the block and return. If there is anything in the path of the pulse to reflect the wave before it strikes the bottom, a portion of the wave will get back ahead of the back reflection and show graphically on the oscilloscope.

How minute a flaw can we find? It is claimed, though I have made no attempt to substantiate the claim, that with the 5 MC Crystal, grain boundaries can be detected. We can differentiate between fine grained and coarse grained steel. And we can find, without difficulty, sulfide stringers, non-metallic inclusions, and very minute holes in a die block. The size of the indication on the oscillioscope does not necessarily vary with the size of the flaw. A sulfide stringer, with waves passing through parallel to its length might not be seen. If the waves pass through at right angles to the length, it will show up like a wart on a nose.

How good a surface must be provided? The better the surface, the more reliable are the results. Smooth forgings with tightly adhering scale can be tested without preparation, but loose scale such as on a hot-rolled bar must be ground off.

How deep will it penetrate in steel? This depends on the density and structure of the steel. Under favorable conditions fifteen feet is possible. Any die block, certainly, can be checked.

Can the Reflectoscope be used on other materials? Yes—any metal and many non-metals.

Does a Reflectoscope guarantee a clean piece of steel? There is a possibility of missing a defect, in traversing a die block with the crystal, but it is a certainty that when an indication shows up, that piece of steel is no good for cavity use.

Can defects be identified with the Reflectoscope? Not positively—but a healthy guess can be made.

Is the instrument practical productionwise or is it a laboratory plaything? Every forging die block leaving Heppenstall's plant is Reflectoscoped. Every die block used by the Doehler-Jarvis Co. is checked before machining.

Does it take long to check a piece of steel? The largest piece used in a plastic die can be checked in one to two hours.

MOLD TEMPERATURE CONTROL

By H. A. MEYRICK

Industrial Manufacturing Corp.

Temperature control of molds and mold design is an established **must** where uniformity of quality and maximum production is desired. The degree or amount of control varies from mold to mold, and in some cases is extremely critical. Examples are numerous in which good control has resulted in astonishing production increases and reduction in scrap. The cost of good control is trivial compared with the losses in operation without it. To accomplish good control it is necessary that the design of the mold be such as to utilize to the best advantage the equipment used in accomplishing the desired results.

Controlling the temperature of molds is controlling the temperature variation that may occur in a mold. These variations are of two basic types. First, there is a variation from one part of the mold to another. Second, there is, or may be, a variation from time to time. Controlling these variations is a matter of designing and building the mold in such a manner as to enable a good controlling process to hold these variations within limits that will permit satisfactory performance.

The limits of permissible temperature variations vary from mold to mold. Examples are numerous in which a variation as little as five degrees F. has resulted in molding problems. One example of this is the surface strains on clear castings which open up into cracks or crazing when the casting is painted. There are numerous examples of this in which lowering the mold temperature by five degrees F. has resulted in these strains. Another example is castings such as instrument dials, panels, etc. having deep characters. The weld lines around these characters sometimes open up when paint is applied. Five degrees F. of temperature drop in the mold has been found sufficient to cause this difficulty. Another example is the dimensional instability caused by fluctuation in the mold temperature of as little as five degrees F. From these as well as other cases it appears that five degrees F. is somewhere close to the limit of permissible variation that some molds will stand. Obviously then the control of mold temperatures must be such that the temperature variations can be held within five degrees F. if desired.

Temperature variations from one part of the mold to another may be caused by improper location of water lines or improper circulation of water. Generally speaking, the best method of securing uniformity of temperature throughout the entire mold area necessitates high velocity circulation of water at a controlled temperature. A simple method of determining the cause of "hot" or "cold" spots is to reverse the flow of water through the mold. As the hot or cold spot moves to another part of the mold the cause of the hot or cold spot may be attributed to the flow. If the spot does not move when the circulation is reversed

it would be well to examine the location or construction of the water lines in the mold.

Water lines in a mold should be engineered into the design along with other integral parts of the mold. Frequently water lines are put in the mold if there is any room left after the knockouts, sliding cores, etc. are built in. This practice frequently results in the water lines being located in the second or sometimes third piece of steel from the actual cavity itself. This introduces a lag in the transmission of heat and too often results in a lack of control. Whereever possible water lines should be located in the steel or metal out of which the cavity or core is made. Where this is not possible it is essential that sufficient water lines be located in the steel surrounding the cavity insert so that the lag between the actual water temperature and the temperature of the polished steel constituting the cavity be less than eight degrees F. Examples are numerous indicating that eight degrees F. is at, or near, the point where control is lost.

The location or spacing of the water lines is a problem which is complicated by the mechanical features which the mold requires. There is very little information known or available as to just where to put these lines. A "rule of thumb" method of water line location is as follows: where the wall section is $\frac{1}{8}$" or less, space the water lines on 2" centers. Where the wall section is over $\frac{1}{8}$", space the water lines on $1\frac{1}{2}$" centers. Use $\frac{1}{2}$" or greater I.D. water lines. It should be emphasized this is a rule of thumb method but it does permit control.

It is recommended that measurements be taken with an accurate surface pyrometer and that these measurements be recorded for analysis. It is suggested that where temperature differences be found in a mold that these measurements be recorded on a blueprint of the mold itself. It is also recommended that measurements be taken from time to time to disclose how close the process is holding or controlling temperatures. If enough temperature measurements are made over a large enough number of molds and over a long enough period of time the measurements can be analysed, and the cause of temperature variations can be ascertained. If the variations are due to improper water line construction this fact can be readily determined. The decision can be made as to what may be done about any particular mold. The accumulation of this information will supply valuable data for future mold design.

It is suggested that a good surface or hand pyrometer be standard equipment in the molding plant. There are several makes of instruments that are rugged and dependable. A good instrument should meet three basic requirements. First, it should have a sensitive or rapid acting tip. Second, it should have a flexible couple between the tip and the instrument. Third, the scale or dial of the instrument should be calibrated so that it can be read to within two degrees F. Standard scales are available with a top reading of 300 degrees F. which meet this requirement.

New Machine

(Continued from page 10)

ber to keep up with the molds proper.

Summing up this paper, we say that we, the machinery manufacturers, must be awake. We must be ahead. We must be alert to the ever expanding field of plastics and work for the betterment of the industry. We should have a joint committee of the machinery manufacturers of plastic molding equipment, and it is almost a must in order to keep ourselves abreast with the material manufacturers and molders and product designers. As individual organizations we do not have the money that these manufacturers of plastic materials have to develop, explore and experiment.

We must remain together for more complete understanding of molders problems and what they wish to do and what they wish to accomplish. We must get together. No idea, no matter who suggests it, is ever a foolish idea. There are no such things as bad suggestions. There are just bad listeners.

MIAMI VALLEY

By JOHN L. RUSSELL

Mr. Stanley Melvin, of the Technical Section, Thermoplastics Division, Monsanto Chemical Co., spoke to **MIAMI VALLEY SECTION** members on February 2, on the subject "Annealing of Styrene Molded Parts—Methods and Results." This was a dinner meeting held at the Peerless Pantry, Miamisburg, Ohio and was arranged by Harold D. Woodmansee, Monsanto Sales Representative and Program Chairman for the meeting.

A new wrinkle was started at this meeting when Charles Selz, of Kurz-Kasch, Inc., Fellowship Committee Chairman, inaugurated a "Meet the Mystery Man" Contest, which proved to be a very delightful pre-dinner get acquainted medium. President Robert W. Gerdes, of the Plastic Moldings Corp., Cincinnati, says that this is just the beginning of a series of surprises for this year's activities.

Questions of National SPE interest were discussed by Mr. Gerdes, B. W. Nelson, Secretary, and W. G. Oelman, National Director, all of whom attended the recent Technical Conference in Cleveland.

Future programs lined up by Program Chairman Martin H. Kasch, include a talk on "Hycar Phenolics" for March, a trip through the Cincinnati Milling Machine Co. plant in April, which is being arranged by Mr. Al Plimmer, and a plant tour of the Sheffield Corp. plant in May.

NEWARK

By JOHN GROESBECK

The first speaker, Mr. Irwin Copland of Monroe Plastics, discussed some of the development work done by his concern in the injection molding of heavy sections through restricted gates. Examples of butyrate screw driver handles were shown to illustrate some of the techniques developed. It was emphasized that accurate mold temperature control plus a great deal of patience were two primary requirements if satisfactory moldings were to be produced. The importance of running an injection machine 24 hours a day 7 days a week in order to reach and maintain balanced operating conditions was stressed. It was Mr. Copland's opinion that as long a period as 48 hours is required at times to reach balanced operating conditions.

The second speaker, Mr. John Boosahda a consulting engineer, told of developments of plastics in India. In 1946, with little or no plastics machinery being exported, a total of 16,000 lbs. of polystyrene was shipped to India. For the first nine months of 1949, a total of $487,000 worth of extruders and injection molding machines was exported together with more than 2,000,000 lbs. of plastics material, mainly polystyrene. It was Mr. Boosahda's opinion that a continuation of this trend could not be expected until the average standard of living of India's 325,000,000 inhabitants was considerably improved.

W. NEW ENGLAND

By WESLEY S. LARSON

A demonstration of the torch welding of thermoplastics was presented before the January meeting of the **WESTERN NEW ENGLAND SECTION** of the Society of Plastics Engineers on January 4, 1950. A talk covering high points of the history and uses of torch welding, and some of the present and potential applications was given by Mr. H. M. Richardson of DeBell & Richardson, Inc. An account of torch welding in England and a demonstration of the process was made by Mr. S. B. King, also

(Continued on next page)

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Klippings from Kosy

By WALTER KOSY

LOUIS A. FISHER has been named president of Fabricon Products, Inc., River Rouge, Michigan, and its subsidiaries. He succeeds Lawrence O. Turner who has retired after over 30 years with the company.

Fabricon Products are manufacturers of waxed paper for food packaging, automotive parts for the motor car industry, and impregnated paper and cloth for the laminating trade. Its subsidiaries are in Cleveland, Pittsburgh, Philadelphia, and Bridgeport, Conn.

News just comes to us of the death of **B. L. BATTY**, technical director of the Rock Island Millwork Co., Rock Island, Ill., of a heart attack on Sept. 30, 1949. Mr. Batty (affectionately known as Bart to his numerous friends) was formerly a sales representative for the Hercules Powder Co. in Detroit and took an active part in organizing the first SPE group here.

Young man on his way up. Announcement has been made that **HARRY HAAXMA**, formerly chief engineer at Wolverine Plastics, Inc., Milan, Michigan, has been promoted to plant manager. Harry was recently elected a director and secretary of the Detroit section of the SPE. Congratulations, boy!

RICHARD BISHOP INJURED AT WORK

Richard B. Bishop is in Cooper Hospital, Camden, New Jersey with severe burns about the head and on the body. He was injured Friday February 3, when hot liquid, which was used in heating a pilot plant for testing catalyst for high octane gasoline, suddenly poured over his shoulders while he was adding a catalyst to the plant. Dick Bishop has just retired from our National Council, where he served as National Treasurer, Chairman of 1949 National Conference and Chairman National Credentials Committee. He has long been active in the Philadelphia Section. Drop him a card. He will appreciate it. His home address is 128 Westmont Avenue, Haddonfield, New Jersey.

Personals—

By PAUL ROCHE

For years this section has looked forward to the possibility of the SPE Annual Technical Conference being held closer to the Erie area, and 1950 therefore should have been like a dream come true, what with all the doings being staged just over in Cleveland (our Ohio suburb). However, since his attendance at the National meeting was to be combined with the Erie visit of our January speaker, we came up with a monthly meeting in direct conflict with the Cleveland schedule. Representing the Northwestern Pennsylvania Section for parts of the conference were Nat Reyburn, Paul Stubbe, Mr. and Mrs. Kenny Erwin, Lloyd Moore, Don Blair, Bob (Monsanto) Wilson, Bob Ely, and Paul Roche, and probably some more that haven't yet been reported.

Jerry Stokes should have and would have been there, but he was head, neck, and heels in jury duty. So, in his absence, his award as co-winner of the prize paper contest was received by this correspondent as his proxy. Jerry is President of Perry Plastics, Inc., of Erie, Penna., and President-elect of this section.

Other newly elected officers are Bob (Sylvania Electric) Wilson—Vice President, "Tony" George—Secretary (re-elected), and Bill Byrd—Treasurer. New section directors are Dick Conner (Presque Isle Plastics), John Specht (Erie Resistor Corp.), and Nat Reyburn (re-elected for a new term).

Chet Berry has entered the engineering department of NOSCO Plastics of January 1950. His 15 years experience in designing injection molds will qualify him well for his activities as coordinator of tooling.

NEW ENGLAND

(Continued from page 21)

of DeBell and Richardson, Inc. The meeting was held at the Sheraton Hotel in Springfield, Mass. An attendance of 55 members and guests were present. The meeting was presided over by Edward W. Vaill, new section president. The remaining new officers were introduced at the meeting; they are Herbert Hasenzahl, vice-president; Robert Crawford, secretary; M. H. Nickerson, treasurer. Door prizes were awarded to a member and a guest with the compliments of the Parker Stamp Works of Hartford.

Torch welding of polyethylene and polyvinyl chloride sheets, rods, extrusions, and wire covering appears to be of the greatest interest. The process provides a means of joining and fabricating polyethylene where no adhesive is available, and in making quick, efficient bonds and seals in all types of vinyls.